MINISTRY OF AGRICULTURE AND FISHERIES,
DEPARTMENT OF AGRICULTURE FOR SCOTLAND, AND
MINISTRY OF AGRICULTURE FOR NORTHERN IRELAND.

REPORTS
on the work of
Agricultural Research Institutes
and on certain other agricultural
investigations in the
United Kingdom.

1930-1931.

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I.

RESEARCH INSTITUTE INVESTIGATIONS.

A.

SOILS, PLANT NUTRITION and PLANT PHYSIOLOGY.

1. ROTHAMSTED EXPERIMENTAL STATION.

The purpose of the work is to obtain information about the soil and the growing plant and to put this information in a form in which agricultural experts and good farmers can use it. The work is done partly in the laboratory, partly in the pot culture house and partly on the two experimental farms, the heavy land farm at Rothamsted and the light land farm at Woburn.

Work described at length in the report for 1929-30 is mentioned only briefly here: this present statement therefore is a selected and not a full account of the activities of the station.

Broadly speaking the laboratory work is concerned with the acquiring of information, while the field work aims at testing the applicability of this information on the farm and also at finding solutions for important practical problems of present day agriculture.

THE FIELD EXPERIMENTS.

The conferences held at Rothamsted, and the visits made by members of the staff to farms in different parts of the country, show that certain general problems are of great importance to large and important groups of farmers; these are studied in the field.

(i) The most efficient use of artificial fertilisers on the land.
(ii) The provision of keep for animals when grass supplies fall short.
(iii) The maintenance of soil fertility in regions where mechanisation is advancing and live stock is being reduced.

(i) The work on *artificial fertilisers* has recently been described in considerable detail in the monograph issued by the Ministry of Agriculture (6); it therefore need not be discussed here. The problems of greatest interest to farmers at the present time are those associated with the proper balance of fertilisers for the expensive crops, potatoes, sugar beet, etc., and the most efficient manuring of grassland. While there are no rigid limits the most economical results are obtained by certain combinations of the necessary fertilisers, and the difference in value between the good and the less efficient combinations may amount to several pounds sterling per acre. The factors determining the best combinations are studied in the field experiments on the Station's own farms and on good farms in various parts of the country; the results are made available to farmers through the Journal of the Ministry of Agriculture, the technical press, and the lectures and demonstrations given by the Rothamsted staff and by the County Organisers concerned.

(ii) Several methods are studied for providing *keep for animals* when grass supplies fall short.

(*a*) *Fodder mixtures.*—Mixtures of leguminous and cereal crops are grown (e.g., vetches, barley, beans), cut green, converted into hay or silage, or allowed to ripen for use as straw and crushed grain. These crops are cheap and easy to grow; they keep down weeds and they have proved of great value as foodstuffs because of their elasticity in use ; no other crops can be consumed in such a variety of ways. The manuring of a mixture, however, differs from that of a single crop, because the element of competition comes in. The crops grown without manure, or with potash or phosphate only, are rich in protein and starch equivalent ; they make excellent feeds. Nitrogenous manures such as sulphate of ammonia and nitrate of soda increase the growth of the cereal considerably but reduce the vetches and peas ; the total weight of crop per acre is greater, but the feeding value is entirely changed. The new crop contains no more protein but more starch equivalent per acre ; it resembles hay of moderate quality.

Several different mixtures are being sown at different times of the year to see how far it is possible to arrange for a sequence of these crops suitable for the needs of a flock master, a dairy farmer, or a crop drying apparatus.

(*b*) *Lucerne.*—The work on inoculation of lucerne is continuing, and search is being made for new strains of organisms more efficient than the one at present being distributed to farmers. These experiments have revealed great differences in effectiveness between different strains occurring in different soils ; none, so far, is as good as the one used by the Station. But the smallness of the number so far studied gives grounds for hoping that the search may be rewarded by the discovery of one that is better.

Nitrogenous manuring proved ineffective to raise the yield of lucerne grown by itself, and it lowered the yield of lucerne grown with grass, besides depressing the formation of nodules and the quantity of nitrogen fixed.

Sales of cultures to farmers have again exceeded all records, amounting to over 9,000 during the season (10, 11).

(iii) *Soil fertility and mechanisation.*—The systematic use of large scale machinery on the farm, called for convenience " mechanisation," is usually combined with a reduction in the number of live stock kept, and hence causes certain modifications in the fertility relationships of the soil. Four important groups of problems are being investigated.

(*a*) Can fertility be sufficiently maintained by artificial fertilisers alone, or is it necessary to return the straw to the land in the form of manure ? If the straw must be returned what is the best way of doing it ?

(*b*) Is it possible to produce by any cultural process the same good effects on light land as are obtained by sheep folding ?

(*c*) Green manuring.

(*d*) Fallowing.

(*a*) The classical experiments at Rothamsted have shown that soil fertility can be kept at a certain moderate level by the use of artificial fertilisers alone without the use of farmyard manure. In general, however, the growth of the crop has not been enough to keep down weeds, and much expense has been entailed in cleaning. A combination of artificial fertilisers with occasional fallows, however, has proved effective in maintaining yields at low expenditure in labour but with a loss of one year in four or five. Where straw is saleable at a profit this method may be adopted. Where however straw cannot be sold—and this is the usual case—it may be converted into manure, so saving some of the fertiliser bill. This is readily accomplished where many animals are kept; the straw is simply turned into farmyard manure. The experiments show that crops obtain about 25 per cent. of the nitrogen of farmyard manure, as compared with about 50 per cent. of the nitrogen of artificial fertilisers. The recovery of potash is higher, being about 60 per cent. But on many farms the numbers of animals are being reduced and the straw must be decomposed in some other way. Investigations into the decomposition of straw have long been in hand in the Bacteriological and Fermentation Departments; four different products can be obtained according to the organisms used and the conditions under which they act:—a mixture of humic substances much like farmyard manure; pentoses; hexoses; and power gas (methane and hydrogen).

The pentoses have little practical importance; the power gas is difficult to handle on the large scale; but the hexoses are the best source of power alcohol, and this particular decomposition may prove to have considerable commercial value. For the farmer, however, the production of humus is the most important of these various changes and it has been studied in considerable detail. A method for converting a heap of straw into artificial farmyard manure by addition of nitrogen compounds, phosphate and calcium carbonate was worked out in these laboratories by Hutchinson and Richards, and developed as a large scale process by the Adco syndicate; it has been successfully adopted by large and increasing numbers of farmers and planters in Great Britain and the Overseas Empire.

Another method is now being studied: the decomposition of straw in the soil. In practice this would have the advantage of requiring less handling of the straw and thus lowering the cost of growing cereal crops. The crop would be "stripped," i.e., the ears cut off with as little straw as convenient, then the remaining straw ploughed in and allowed to decompose in the ground. The laboratory experiments show that the decomposition of the straw requires a warm temperature and a sufficient supply of nitrate or ammonium salts; if therefore the straw is ploughed into the ground in autumn while the soil is still warm and fairly rich in nitrates, the decomposition should be fairly rapid and inexpensive, seeing that the nitrates would be largely washed out if they were not utilised in this way. If, however, the straw is not ploughed in until late winter, when the soil is cold and much of the nitrate has been leached out, then decomposition is slower and may be disadvantageous to the crop by using up nitrates that would otherwise have increased its growth. Two sets of field experiments have been started to deal with these problems.

(*c*) *Green manuring.*—This affords a simple method of manuring both heavy and light soils, and it requires no live stock; it can be practised on completely mechanised farms. Its advantage in certain conditions has long been recognised, but of late years a number of instances has been recorded where it proved ineffective. The most striking is at Woburn, where, over a series of years, green manuring with tares and with mustard has failed to increase yields of wheat. Experiments carried out a few years ago on several other farms with the help of a grant from the Royal Agricultural Society of England also yielded negative results.

There are, however, undoubted successes, and investigations have been made and are still in progress to find the conditions under which green manuring is likely to give useful results. Two of the most important factors are the composition of the plants at the time of ploughing in and the time at which the ploughing is done. If the ratio C.N in the crop exceeds a certain value (usually about 20), the organisms effecting the decomposition require more nitrogen than is supplied by the crop, and so they draw on the soil nitrates that would otherwise either be washed out or taken by the plant. If, however, the ratio is less than this value, the organisms do not need the whole of the nitrogen and they leave the excess in the soil in the form of nitrate which as before is either washed out or taken by the plant. Investigations have shown that at Woburn the tares crop failed to increase the growth of wheat because it was ploughed under in autumn, and rapidly gave rise to nitrate which the wheat plant, being insufficiently developed, could not assimilate, so it was washed out, and in the following spring the wheat suffered from nitrogen starvation. The mustard assimilated nitrate and so saved it from loss, but it liberated it too slowly to be of use to the wheat (12). The value of nitrogen depends on the time when it is given; when given late to barley it reduces the ear tillers and the number of fertile grains and increases the vegetative tillers. It seems clear that the process of green manuring needs to be closely adapted to the soil and the crop so as to ensure liberation of nitrate only when the plant is in a position to take it up (13).

Cultivation.—These investigations are carried out jointly by the staffs of the Soil Physics Department and of the Farm; the field work consists in comparing the tilths produced by the traditional methods with those obtained by certain new kinds of implements, especially those which aim at getting a tilth in one operation, such as a rotary cultivator, and the "pulverator." Measurements are taken of the soil conditions, the rate of germination of the seedlings, growth of the crop and of the weeds, and of the final yield.

The usual result is that the rotary treatment leads to better seedling growth both of weeds and of sown crop, but under present methods of working this early superiority of the crop is lost later on and no difference in yield is obtained at harvest. It should be possible by suitable modification to maintain the early advantage, and as soon as this can be done a distinct advance in cultivation methods could be expected.

During the year a new type of field experiment was initiated: a combination of manurial and cultivation trials, and the results were so interesting that further experiments of the kind will be made.

The possibility of crop drying.—Several kinds of crop drying plants are now on the market; their successful use on the farm would turn largely on the length of time during which they could profitably be employed. Experiments are being made to find good sequences of crops so as to ensure continuous use of the machine for as long a period as possible; it is hoped for seven months.

Methods for agricultural soil survey.—In recent years there has been marked development in the number and extent of the soil surveys undertaken in this country and elsewhere, and it has become essential to work out satisfactory methods for field and laboratory examinations. Much progress has already been made in the United States and in Russia. The Russian methods have been studied by several members of the Rothamsted staff. In order that a careful study of the American methods might be made, Dr. L. L. Lee, one of the leading soil surveyors of the United States, was invited to Rothamsted for a year, during which time he made two typical surveys: a detailed survey of the Rothamsted farm, showing how the methods are used in making an intensive survey of a small area, and a more general survey of Kent, showing how they deal with a large area in a limited space of time. A number of meetings took place with soil surveyors in this country, out of which emerged agreements as to procedure which will prove of great value for future work (33). One of the best of the German "Kulturtechniker," Dr. Janert, was also invited here for a year to apply his heat of wetting and other methods to the British soil problem.

PLANT PESTS AND DISEASES.

Insecticides.—For some years past much attention has been devoted to pyrethrum, one of the most effective and convenient of all insecticides whenever it can be applied. Ground samples of the flowers, or dust preparations of pyrethrum are, however, liable to loss of toxicity if exposed to light and air. Dr. Tattersfield has discovered the cause of the loss of toxicity; he finds that the poisonous principle readily oxidises, particularly in dusts. He has also shown how to avoid the loss; if certain anti-oxidants such as pyrocatechol, resorcinal, hydroquinone, pyrogallol and tannic acid are mixed with pyrethrum dust, they protect the poison against oxidation and so preserve it. The method has proved successful in laboratory trials, and has been patented.

Work is being continued on the very valuable insecticides obtained from derris and haiari grown in certain tropical parts of the Empire. Unfortunately it is somewhat costly and the need for economy has compelled a restriction of this part of the programme. Special arrangements have been made with the Empire Marketing Board for the detailed examination of some of the more important of the samples now being grown experimentally in British Guiana in the hope of developing a new industry there.

Insect pests.—The pigmy mangold beetle (*Atomaria linearis*) has of late years been a troublesome pest of mangolds, and its life history could not be worked out because neither the eggs nor the larvae could be found in the soil. This has now been done by Mr. Newton, and it therefore becomes possible to gain further knowledge of the pest, which may lead to the discovery of suitable remedies.

The work on gall midges of willows (56), clover and other plants has been continued.

Bacterial and fungal diseases of plants.—Owing to its technical importance in large parts of the tropical Empire, the angular leaf spot of cotton is being investigated in great detail. The organism causing it (*Bact. malvacearum*) is extraordinarily interesting as a bacterium, because it has been shewn to possess a nucleus and to pass through a stage in which two cells fuse to form a zygospore (76). Several strains occur which fall into two main groups, one of which is considerably more virulent than the other. The disease is greatly favoured by high air temperature and high humidity ; it is greatly reduced below 30° C. or 75 per cent. humidity. These observations show the conditions under which the disease may be expected to become important ; further work is being done in the hope of finding a remedy (75). This work was made possible through a grant given by the Empire Marketing Board for the erection and maintenance of the expensive equipment required.

The quantitative methods worked out in the Department have been used by J. Singh for estimating the numbers of fungi and actinomycetes in the Rothamsted soil. The types of fungi were much the same in the differently manured plots, but the numbers both of types and of individuals were always higher on the more fertile plots. There was no evidence of seasonal fluctuations in numbers such as had been recorded for bacteria and for protozoa. Barnfield (continuous mangolds, the leaves always ploughed in) contained more fungi but less actinomycetes than Broadbalk (continuous wheat) ; there was some difference in the proportions of the fungal population. Barnfield contained more *Penicillia* and *Dematia* but less *Fusaria* and *Verticillia* than Broadbalk.

Virus diseases of plants.—

(i) *The nature of virus.*—Evidence has been accumulated that virus does not exist diffused throughout the infective material but in a particulate condition. This may be because it is itself particulate or because it is attached to other particles, and work is in progress to determine which is the true explanation. It is frequently asserted that viruses are invisible stages in the life-cycle of visible bacteria, largely because there is a regular association of specific bacteria with certain virus diseases. We have investigated one such case, and find that, when the plants are grown aseptically throughout, the disease develops characteristically without the appearance of the usually associated bacteria (73). It is also said that intracellular inclusions which are characteristic of virus disease are either colonies of the virus or visible stages of a usually invisible parasite. The development of such inclusions has been watched in individual living cells from their first beginnings to their complete formation, and it has been shown that in the cases investigated they are essentially aggregates, made up by the coalescence of small particles of cytoplasm which have been locally coagulated or precipitated under the influence of the virus.

A cinematograph film has been prepared showing the whole process. The final form of the inclusion varies with the host plant and with the virus.

(ii) *The behaviour of virus in, and its effects on, the host plant.*—It has been found that within the infected plant the virus does not travel in the transpiration or water stream, nor indeed does it normally enter the stream. If deliberately introduced into the xylem vessels, it cannot normally escape ; it therefore does not produce the disease unless and until it is artificially liberated. It appears, from a series of different experiments devised to test the point, that virus does not enter an unbroken cell. Its entry into the leaves of an infected plant is followed by considerable alterations in the enzyme content and in the mechanism of respiration (78).

(iii) *The relation of virus to insect-vectors.*—By the development of a technique for maintaining insects upon solutions apart from the plant, considerable control has been obtained over the conditions determining the infection of the insect. Data have been obtained as to the time required for dyes and other substances taken in by the alimentary canal to reach the salivary glands, information which is necessary for the correct evaluation of the incubation, or non-infective period after the insect has fed upon diseased materials. A new virus disease has been discovered in *Hyoscyamus*, which is readily transmitted both by needle and by aphis, and has an incubation period in the aphis.

This work is being carried out with the aid of a grant from the Empire Marketing Board.

BEE RESEARCH.

In drawing up the programme of bee research the department is assisted by a committee of practical bee keepers who report from time to time the problems, apart from disease problems (which are outside the scope of the grant), which are of special concern to them. The chief problem has been the study of the differences between the "warm way" and the "cold way" of arranging the frames in the hive; the warm way being the one in which the frames are placed parallel to the front so that the first frame acts as a kind of door shutting off the rest, while in the cold way the frames are placed at right angles to the front. The differences were only slight, but by taking numerous observations continuously for several years, certain conclusions have been reached.

(*a*) In summer the temperature inside the hive is almost entirely independent of the temperature outside, and completely independent in the brood chambers.

(*b*) In winter the temperature inside is affected by that outside; it changed by 0·6° to 1° for each 1° change outside, and the change was greater in the "warm way" hives than in the "cold way" hives, especially on the north and east aspects.

(*c*) In spring and autumn the inside temperature seems to vary with the outside temperature.

A second question asked by the practical keepers was whether cane sugar or beet sugar is the more suitable winter food; there is a strong feeling in favour of cane sugar. Prolonged trials, however, failed to reveal any difference.

An investigation of more general interest has been started during the past year. A glass observation hive has been set up into which bees are introduced shortly after their emergence from the brood stages; they are marked so that they can be recognised and their movements followed.

The observations indicate that the duties of the hive are allotted to the bees in order of their age; the youngest are called upon to do certain things; when they are older they pass to other duties; there seems to be a regular sequence. The bees were induced to swarm; a few days before the migrants left home some of them were seen three-quarters of a mile away from home preparing an empty hive for occupation. When finally the swarm went off it took with it bees of different ages in approximately the same proportion as in the parent hive. This work is being developed for the purpose of studying the cause of swarming.

THE FARM.

The reorganisation of the farm is now practically completed, it has been changed over from an entirely arable farm to a more general type with 50 per cent. of its area under grass and a considerable head of live stock which is proving very useful in enabling the experimental programme to be widened so as to include problems of farm management.

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2. MACAULAY INSTITUTE FOR SOIL RESEARCH, ABERDEEN.

Special investigations.—The studies of a Scottish drift soil which have been going on for many years under the supervision of Professor Hendrick are being continued, and at present detailed investigations are being made of two profiles at Craibstone, one on cultivated ground and the other on adjoining uncultivated ground.

A piece of work on the lime status of certain Scottish soils has been commenced, and in conjunction with the Scottish Animal Diseases Research Association problems in connection with the malnutrition of mountain sheep are being studied, particularly in relation to possible iron deficiencies.

A survey of the peat land of the Island of Lewis has been commenced, and samples drawn for chemical and pollen analysis with a view to comparing the typical scirpus peat of the island with moss and heath types on the mainland (1).

Mr. Monie has continued his researches on land drainage, and the results of this work were seen at a demonstration at the Lewis farm, where the draining machine cut open drains of excellent finish on peat land at a speed of 2 miles per hour, and at a cost of £1 per mile. He has also continued his experiments on the measurements of soil texture by means of an auger (in an endeavour to obviate the necessity for mechanical analyses in certain cases), and has been studying the problem of satisfactorily measuring and describing soil colours.

Progress has been made with survey work in Renfrewshire, Dumbarton and various other areas.

Pot experimental work.—A series of experiments has been carried out in Mitscherlich pots in conjunction with Mr. Moore, of the North of Scotland College of Agriculture. Some of the soils studied were from areas where clover and oat failures were known to occur and a number of experiments on peat from Lewis were also carried out.

Geological work.—The determination of the mineralogical composition of soils in the south-eastern area of Scotland was continued into the north-eastern area, a special study being made of part of Kincardineshire. This area of rather complex geology has been recently surveyed geologically, and an attempt is being made to classify the parent materials (glacial clays and sands mainly) to be of service for a soil survey. The mineralogical work has been carried out on the matrix of the clays to obtain a knowledge of the composition of the parent material, of the changes due to weathering processes in soil formation, and also for comparative purposes.

A start has also been made in obtaining information as to the extent and distribution of waste land in Scotland. The published maps of the Geological Survey are being used for this purpose, two areas, one in the Lowlands and the other in the Highlands, being selected. These maps give the distribution of peat where it is two feet or over in depth, and should form an excellent basis for a more detailed survey for agricultural purposes. The 6 in. manuscript field maps, which contain much additional information, are also being collated in this connection.

Craibstone drain gauges.—The drain gauges in 1931 were under third-year grass, and this was regarded as an opportunity for measuring how far the nitrogen used in intensive nitrogenous manuring of grassland is utilised by the crop, how far it is lost in the drainage, and what is the effect of its use on the other constituents of the drainage and on the composition of the crop. The system of manuring grassland intensively with sulphate of ammonia, after a dressing of phosphatic and potassic manure has been given, has recently been attracting much attention in this country, and many experiments have been carried out in Scotland, England and Ireland. This was an opportunity of investigating this question from a different angle, and under conditions where the fate of the nitrogen supplied in the intensive nitrogenous manuring could be traced with a considerable degree of accuracy.

Drain gauge No. I was as usual unmanured, while Nos. II and III received applications of phosphate and potash manure in November, 1930, and were treated with dressings of sulphate of ammonia in 1931. The first dressing, 1½ cwt. per acre, was given in March, and further dressings were applied in May and September ;

the total nitrogenous manure applied during the season being 4 cwts. per acre. The crop was cut at frequent intervals to represent as nearly as possible the grazing of such grassland stock. The crops were weighed, the amount of clover in each cutting determined, and analyses are being made in every case. The composition of the drainage and the amount of nitrogen contained in it are also being determined. The season 1931 proved to be a wet one, especially during the first six months of the year, and drainage was recorded in every month. Nevertheless no ammonia was lost from drain gauges II and III, and so far as the analyses go little more nitrate has been washed from these drain gauges than from No. I. A complete report of these experiments will be published when the analyses are completed.

Lewis Farm.—The acreage under cultivation at the Macaulay Demonstration Farm has been considerably increased and various experiments begun with a view to obtaining satisfactory pasture on the moorland at a low cost. The areas previously laid down to pasture have done well and have provided good grazing for the cows during the summer ; pasture experiments are also being conducted on skinned land (land from which the peat has been removed for fuel). A vegetable garden has been laid out and good crops of a variety of different kinds of vegetables obtained.

Silage and oats were again grown successfully, but difficulty was experienced with potatoes on account of the ground being too soft for horse labour.

In cultivation promising results have been obtained from a Swedish harrow drawn by a caterpillar tractor, and this type of tractor has also proved useful in drawing a drainage plough.

A wooden stave silo has been erected at the farm, and the dairy herd increased.

Title of paper issued during the year.

1. Ogg, W. G., Garst, J. and Macleod, A.: Reclamation and cultivation of peat land in Lewis. II. *Scott. J. Agric.*, **14**, 2, 131, 1931.

3. CHEMICAL (AND ANIMAL NUTRITION) DIVISION, MINISTRY OF AGRICULTURE FOR NORTHERN IRELAND.

Soils and fertilisers.—The manurial treatment necessary for potatoes grown on freshly broken bogland has been investigated during the past two seasons. The bog, after hand digging, received a heavy dressing of pig manure and trial plots were laid down which received various dressings of lime and fertiliser mixtures. Satisfactory crops were obtained but further trials are necessary before definite conclusions can be drawn.

During the year the manurial requirements of several soils were examined by Mitscherlich's pot culture method and deficiencies were indicated in a number of the soils under examination. It is hoped to check these results in the coming season by means of field trials.

Titles of papers issued during the year.

1. Baird, J. C., and Duff, W.: Investigations during 1928 and 1929 into the effect of flax water on fish life. *J. Min. Agric. N. Ireland*, **3**, 49, 1931.
2. Baird, J. C., Potato manurial experiments. *Ibid.*, **3**, 124, 1931.

4. RESEARCH INSTITUTE FOR PLANT PHYSIOLOGY, IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY.

The interaction of factors in plant growth and yield.—The study of the interaction of the manurial factors in the growth of barley which has been in progress for some time has been further extended to cover the interactions of nitrogen and potassium. Twenty-five combinations of the manurial elements in varying proportions were investigated in sand culture, and the usual quantitative data of growth were collected at weekly intervals during the life cycle. Full data of leaf-area growth, rate of production of leaves and tillers, ear emergence, flower numbers and fertility for all combinations are thus available. In addition three series of the cultures were sampled at fortnightly intervals, namely one series with nitrogen in excess and potassium in five stages of increasing deficiency, a second series with potassium in excess, and increasing nitrogen deficiency, and a third with both constituents at five different levels but at constant ratio to each other. Analyses of the plants from the samples for nitrogen and potassium content are at present being carried out. Previous study of nitrogen and phosphorus interaction in 1926 showed that the problems of the form of the yield curve, the physiological balance, and the efficiency in utilisation of fertiliser constituents were very closely related, and indeed were merely different aspects of the same problem. It is hoped to publish these results in full during the current year. It has already been shown that the effect of potassium is primarily on the processes in respiration and assimilation and only secondarily on meristematic processes, whereas phosphorus acts primarily on meristematic processes and secondarily on respiration and assimilation. A comparison of the interactions of these two elements with nitrogen is therefore of particular importance.

In connection with the problems of interaction of factors reference may be made to large scale field experiments carried out at the Gezira Research Farm, Sudan, in collaboration with this Institute. The experiments concerned the problem of cotton grown under irrigation. The interactions of four factors were studied, namely, water-duty, sowing date, spacing, and nitrogen application. In all, 72 combinations of these factors were investigated. The methods used were similar to those employed in the barley investigations and the results have proved the practical utility of the methods and have shown the importance of interaction studies in determining optimal conditions, and in enhancing control of yield by utilising suitable combinations of factors. A preliminary account of the experiment of 1929-30 has already appeared (6).

The physiology of barley under conditions of mineral deficiency.—The effect of manurial deficiency on the growth and characteristics of barley has been studied in previous years. An attempt is now being made to obtain some further knowledge of the nature of the physiological changes induced by such deficiency. A study of the sugar content of the barley plant has therefore been undertaken, and to this has been added a study of some of the nitrogen changes. Plants grown in sand cultures, receiving complete nutrition, and nutrients deficient respectively in nitrogen, phosphorus and potash, were analysed at intervals. Eight samples of leaves and stem were taken throughout the growing season and, at the last sample, of the ears also. The first four leaves of the various series showed no marked differences in reducing sugar, but from the 5th leaf onward marked differences appeared. Nitrogen deficiency induced a large increase in cane sugar, reaching a maximum at the 6th leaf and then declining rapidly. Reducing sugar in this series showed a minimum at the 3rd leaf and a subsequent steady rise to the 10th leaf. Phosphorus deficiency had little effect on the cane sugar but the reducing sugar after reaching a minimum at the 4th leaf rose to a threefold value at the 7th leaf, followed by a fall. Potash deficiency also led to a minimum of reducing sugar at the 4th leaf, after which the value remained steady up to the 8th leaf and then rose rapidly to the value shown by the other series. The cane sugar content fell steadily to a low minimum at the 6th leaf followed by a slow rise to the 8th and then a rapid increase to the 10th. With regard to nitrogen the various series, apart from that subjected to nitrogen deficiency, showed little difference in total nitrogen content. Asparagine and amino nitrogen were, however, much increased by both phosphorus and potash deficiency, the first being much higher under phosphorus than under potash deficiency. The full results of the nitrogen determinations are not yet available.

Electro-culture investigation.—The results of the work for 1930 have been put together in the form of a report to the Ministry of Agriculture and Fisheries (4). The pot-culture experiments of 1930 have confirmed those of earlier years and have shown a much more sharply marked relationship of the electrical effect with manuring. The increased grain yield resulting from electrification has been confined to the plants with medium nitrogenous manuring.

Those without additional nitrogen showed no significant increase and those with high manuring (8 gm. sodium nitrate per pot) showed a decrease. A period of electrification for about the second six weeks of growth again has been shown to be the more effective, and to be much more effective than a period ending at the same time but starting three weeks earlier. With this longer period there was in fact no significant increase in yield though some slight effect on tillering and ear emergence was observed. This result shows how important it is to define closely the point at which electrification should begin. The effect of the discharge in reducing the percentage of sterility in the ear has again been observed. A further analysis made this year has shown that the effect operates mainly on the smaller ears which would normally bear less than 25 flowers. As the result of electrification the number of ears in the class with 25–29 fertile flowers was increased by 85 per cent. in the plants with moderate nitrogenous manuring. The effect of the discharge on tiller production and the rate of growth of the tillers has been again observed. In addition the important observation has been made that in the case of the pots showing an increased grain yield there is a considerable reduction in the weight of the root system as determined at harvest ; this requires further investigation. It has been demonstrated that the increased yield produced by the discharge is associated with an earlier emergence of the ears. In the electrified sets with moderate nitrogenous manuring no less than 44 per cent. of the ears showed their awns by July 2nd while at that date the control series showed only 29 per cent. The same plants had on August 16th only 5·1 per cent. of unripe ears while the controls showed 7·5 per cent. The action of ionised air, which has been shown to be effective in the increase of rate of respiration of barley seedlings, was tested in the case of a fungal culture ; such air was, however, found to produce no effect (5).

Potassium in the potato.—The distribution of potassium in the potato plant has been investigated (7) and the movement of potassium in the plant has been followed. The leaves show a gradual increase in content rising to a maximum in July. Later they lose the potassium to the stalks and tubers. There is a circulation of potassium in the plant resulting from a rise in the water stream and a downward flow in the stem, no doubt in the phloem.

The after-effect of temperature on winter cereals.—An investigation has been begun of the effect of temperature during the germination of barley, oats and rye. The work of Gassner and Maximov on the effect of an early high temperature in later retarding or inhibiting ear-formation in winter cereals has been confirmed and an analysis of the effect undertaken. Systematic examination of the ear primordia has shown that failure of flower production in winter cereals germinated at temperatures above 5°C. is not due to failure to produce such primordia. The primordia are in fact laid down at the same time irrespective of the temperature of germination, but, whereas vegetative growth, i.e., rate of production of leaf primordia, is unaffected by the temperature of germination, the production of flower primordia in the winter cereals germinated above 5°C. is extremely slow, and the stem elongation which accompanies flower differentiation fails to take place. It has been shown that a seasonal factor is concerned, presumably length of day, and that under short-day conditions the temperature after-effect is either reduced, as in oats, or disappears altogether, as in rye.

Physiology of tomatoes grown under glass.—A survey has been begun of some of the physiological aspects of the commercial production of tomatoes, particularly in regard to the balance between light and temperature, the most suitable carbon dioxide concentration of the surrounding air, and of the leaf activity in relation to age of plant. In pursuance of this work special methods have been developed for the measurement of light intensity, for the determination of leaf area, and for the rapid drying and weighing of numerous samples of plant material. The study of the action of enhanced concentration of carbon dioxide will be continued as part of this major investigation, as it has been shown that such action is markedly affected by other conditions such as light and age of plant.

Vegetative propagation.—The work on vegetative propagation and stock-scion relationship in the apple has been continued at the East Malling Research Station.

Biochemical work.—A study has been made of the ripening processes of the apple and the changes occurring during storage (1, 2). In relation to this work various special methods for the estimation of starches and sugars have been examined and improved (3, 8).

Titles of papers issued during the year.

1. Archbold, H. K.: Ripening processes in the apple. *Proc. IXth. Internat. Hort. Cong.*, 1930.
2. ———: Chemical changes in stored apples. The relation of the time of picking to the chemical composition and storage life of the apple. *Proc. 1st. Imp. Hort. Conf.*, 1930.
3. Archbold, H. K., and Widdowson, E. M.: Iodimetric determination of reducing sugars in the apple. *Biochem. J.*, **25**, 101,1931.
4. Blackman, V. H.: Thirteenth interim report to the Electro-culture Committee of the Ministry of Agriculture and Fisheries, 1931.
5. de Boer, S. R.: The effect of ionised air on the rate of respiration of fungi. *Ann. Bot.*, **44**, 176, 1930.
6. Gregory, F. G., Crowther, F., and Lambert, A. R.: The interrelations of factors in determining the growth of the cotton crop in the Sudan. *Emp. Cott. Growing Corp.*, 1930.
7. James, W. O.: Studies of the physiological importance of the mineral elements in plants. II. Potassium; its distribution, movement and relation to growth in the potato. *Ann. Bot.*, **45**, 179, 425, 1931.
8. Widdowson, E. M.: A method for the determination of mixed reducing sugars and its application to the estimation of the products of hydrolysis of starch by taka-diastase. *Biochem. J.*, **25**, 3, 1931.

B.

PLANT BREEDING, CROP VARIETIES and SEEDS.

5. PLANT BREEDING INSTITUTE, CAMBRIDGE UNIVERSITY.

Wheat.—During 1930–31 the wheat investigations covered much the same range as in the two preceding seasons. They were in part of an exploratory nature, but most of the work was of the usual routine nature which is associated with the improvement of the crop. In the former category comes a detailed study of the genetics and cytology of interspecific crosses (A. E. Watkins). This was again supplemented by a systematic study of all available types of wheat. Those under examination were obtained mainly from the Himalayas and eastern Asia. They proved of considerable interest not only to the plant systematist, but especially to the pathologist on account of the striking differences in disease susceptibility of wheats from different districts. But none of them offered any possibilities of being of immediate value for cultivation under English conditions.

The cytological investigations on interspecific crosses have done much to explain the difficulties previously encountered in the attempts to make use of wheats other than those belonging to the bread-wheat group for the improvement of the crop. It now seems practicable to synthesize bread-wheats with, for instance, the extreme winter hardiness of some of the spelt wheats or, again, the yellow rust immunity of some of the club wheats. Work on these problems has consequently been started and when the opportunity can be found it will be extended to wheats of the Rivet group.

The genetical observations on the inheritance of well-filled grain were continued. A plant showing this feature rather markedly occurred six years ago in a cross between Square Head's Master and a Chinese wheat. The character now appears to be independent of seasonal conditions and, further, it is segregated sufficiently distinctly in the F_2 and F_3 generations to make selection possible.

Further attention has been paid to the question of raising wheats capable of producing satisfactory loaves without admixture with imported strong grain (F. L. Engledow). With previous experience as a guide unusually rapid progress has been made. Using Yeoman II as one of the parents and an excellent pure line of White Fife as the other, a number of strong-looking, stable types were obtained in the F_4 generation. The grain stocks were then increased for laboratory tests and this season a sufficient supply of some of the best forms was available for complete milling and baking trials. These indicate that a considerable advance in the baking quality of wheats suitable for growth under English conditions has been made. Several of these new forms are now being tested out by the National Institute of Agricultural Botany.

Another series of Yeoman II hybrids was raised some years ago with the object of securing wheats suitable for a wider range of soil and climatic conditions than the type itself, which experience has shown lacks the "adaptability" of Square Head's Master.

Small scale trials of six of these were made in various districts in 1929–30 and 1930–31. The tests have disclosed unexpectedly wide differences in their cropping capacity, though, as grown in Cambridge, there was nothing to choose between them in this respect. They tend to confirm the suspicion that the selections made in the past have been biassed by soil and climatic conditions more than had been anticipated. A further series of these crosses was therefore made this season with the object of employing another method for attacking the problem in the near future.

The collection of forms of Rivet wheat was again under detailed observation. Sufficient information was accumulated to enable provisional decisions to be made as to which were most suitable for large scale propagation.

Winter oats.—During the autumn of 1930 quantities of seed, varying from three to six stones, of the most promising selections made from Argentine × Grey Winter were handed over to the National Institute of Agricultural Botany for propagation. Judged on the information obtained in eight successive seasons, these forms possess the desirable combination of winter hardiness, strength of straw and high quality of grain.

Anticipating to some extent the results that the National Institute of Agricultural Botany might obtain in regard to strength of straw and grain quality, in two of the new oats at least, further single plant selections of these were made two years ago. The produce of the usual propagation plots was again sufficient to enable the Plant Breeding Institute to hand over three stones of seed of the best forms to the National Institute of Agricultural Botany this autumn. Arrangements have been made to continue this procedure and thus maintain a regular supply of seed to the National Institute of Agricultural Botany of such oats as are finally chosen for extended propagation.

The winter 1930–31 was not such as to amplify the information on the resistance to winter conditions secured previously. The effect of the weather experienced in the latter part of the cereal year, however, afforded an excellent opportunity of judging the strength of the straw.

In order to arrive at some idea of the comparative yields of the new forms, a chequer-board test, consisting of fifteen replications of five selections and of the parent Grey Winter, was sown in one of the cages. This test showed that four of the five selections were superior to the parent (Grey Winter) by significant amounts, whilst in point of quality they are in close agreement with the findings of previous years. These determinations, supported by the results of similar tests that they have made themselves, have enabled the National Institute of Agricultural Botany to include two of the new forms in their strip trials for the coming season (1931–32).

An entirely new series of winter oats, obtained from what appears to have been an out-cross, has reached the propagation stage. These oats possess in a marked degree the following desirable characters—winter hardiness, strong straw, good quality of grain, and decided earliness in ripening.

Apart from the above, which may be regarded as being in a relatively advanced stage, another series consisting of back crosses of the most promising forms obtained from Argentine × Grey Winter with the Grey Winter parent has now reached the F_3 stage. Owing to limitations of both space and staff, it is impossible to propagate all of these simultaneously, but it is hoped to concentrate on 136/17 × Grey Winter. This particular lot has been chosen because it proved to be the best standing oat this season (which was one of the severest tests of straw experienced for some years) and, according to the chequer-board test, the most prolific grain-producer.

Spring oats.—The weather conditions this year have expedited the selection of certain new hybrids which have been under observation for some years. Hitherto sufficient evidence on their standing capacity was not available, but now that this has been obtained the large scale propagation of the best forms can be commenced.

Barley.—During the last two or three years a narrow-eared rogue has been found in commercial stocks of Spratt-Archer barley. This rogue produces a decidedly inferior malting grain. Last year a large number of single ears of Spratt-Archer was selected and sown individually this year. On examination of the produce it was found that in some cases the rogue still appears, but in others it is apparently absent. The best of these single plant cultures are being selected on the basis of appearance and nitrogen content and will be further propagated in 1932 and subsequently until sufficient material is obtained to hand over to the National Institute of Agricultural Botany for extended propagation.

The investigations on the possibility of breeding six-row barleys of good malting quality were continued on the lines described in previous reports.

Other crops.—Sufficient stocks of the new lines of field peas and beans were obtained for extended trials in 1932. Information on their cropping capacity and, in the case of the peas, on the most suitable length of haulm for agricultural practice is necessary before further progress can be made with the improvement of the crops. The experimental work with lucerne was interrupted by weather conditions; the few crosses attempted failed and the stock plants produced very little seed. A useful stock of seed of the sugar beets selected in the previous season was obtained. The roots, instead of being grown on under pollen-proof, and hence moisture-retaining covers, were set out on sufficiently widely separated positions to be reasonably safe from wind-borne pollen.

6. WELSH PLANT BREEDING STATION, ABERYSTWYTH.

Introduction.—The main researches of the Station are financed partly from the Development Fund, and partly from the Empire Marketing Fund. Special grants are also made to the Station from the Development Fund for research on the improved management of grassland (see p. 337), and from Messrs. Imperial Chemical Industries, Ltd., for general grassland researches. Having regard to the policy which underlies all the researches of the Station it is impossible to segregate the various investigations and to deal with particular researches as exclusively financed from a particular grant. There is inevitable overlapping, or rather dovetailing of all these investigations into each other. It is worth emphasising that the whole resources of the Station are concentrated on the solution of one major problem, and every single investigation that is undertaken is planned with a view to assisting in the solution of that major problem, and not with a view to the solving as such of isolated scientific problems of problematical practical value. The major problem is to place the improvement and management of grassland on a sound scientific basis of economic production. It is a practical problem which necessitates not only ascertaining new scientific facts, but equally, and probably to a greater extent, finding out, by the adoption of a sound scientific technique, how to bend the already known facts of science to the solution of the major problem. The Welsh Plant Breeding Station is, in short, entitled to claim for itself that it adopts very much the outlook and technique of the engineer.

This is true as applied to the Station's oat breeding work, which from the outset has been conducted in a manner subservient to grassland. Special endeavour is being made to breed good standing varieties under which seeds mixtures can be sown with every promise of success. Endeavour is also being made to breed varieties suitable for the highest elevations and the poorest conditions—this primarily because ploughing and re-seeding is one of the soundest methods of improving very poor grasslands. In this latter connection winter oats are very important, because if of good standing ability they make a suitable nurse crop and give an extended scope for ploughing and cultivating. Again the problem as a whole in its practical implications is kept constantly in view relative to the Station's researches on the plant breeding and seed production of herbage plants. Thus with the poorest lands in view grasses like Yorkshire fog and sheep's fescue are brought under study—while it is realized that for the seeding out of open hill land and poor lands in general (see report on the work of the Grassland Adviser, p. 335) farmers must obtain the right seed, and cheaply, and this will probably be best achieved if they grow it for themselves. Seed production trials are, therefore, being conducted over the widest possible range of soil types and at a variety of altitudes.

Everything to do with the technique (practical technique) of seed production is regarded as being of first-rate importance, indeed of pivotal importance relative to the aims that the Station has in view.

In connection with the actual plant breeding it is of course essential to conduct a number of genetical researches relative to the general behaviour of the species under study, but the precise extent to which it is necessary to embark upon such researches in relation to economic issues is undoubtedly the most difficult of all the questions which have to be settled as affecting the research programme.

The progress that is being made with the various investigations is indicated by the notes which follow.

OATS (MR. E. T. JONES).

White winter oats.—In view of the excellent results given by the most promising strains of the Kyko × Grey Winter cross, an experimental distribution was made of seed stocks of S.81 and S.82 during the autumn. Quantities of these were readily taken up over a wide area throughout the Principality and should in the coming season provide a good indication of their suitability and desirability under Welsh conditions. These two strains are also being tested under the National Institute of Agricultural Botany scheme of variety trials in England (1).

Spring oats.—Progress is being made towards the reduction of the many segregate selections in hand, of the Victory × Algerian, Victory × Record and Golden Rain × Algerian crosses, to a manageable number for more extended trials on a field scale. Several strains continue to show promise in ability to withstand lodging. These have plump grain and yield well relative to the check variety. Some, however, are inclined to be somewhat late in ripening. One strain (258 Cn 41/16, Golden Rain × Red Algerian) this season has shown marked resistance to attacks of crown rust.

Of the selections under test for soils of only moderate fertility those derived from the crosses Record × Radnorshire Sprig and Golden Rain × Radnorshire Sprig continue to give promising results on a basis of grain yield, grain quality and resistance to lodging. This season's rod row trials with 36 strains will enable eliminations of many strains to be made, and about 16 have been tentatively selected for extended trial in 1932. These selections are about the most promising of any in the oat-breeding trials at the present time, and their grain-yields compare very favourably with those of the Victory × Algerian series. Work has also now begun on the development of a number of segregate strains of the crosses Black Bell III × Victory and Black Bell III × Radnorshire Sprig.

Oats for upland conditions.—Small bulks of four segregates of a cross *A. strigosa* × *A. brevis* have now been developed and are available for preliminary trials under upland conditions during the coming season. Numerous other selections of this cross are under study and also a few promising segregates from the diploid-tetraploid cross *A. brevis* × *A. barbata*.

HERBAGE PLANTS : BREEDING.

Grasses (Mr. T. J. Jenkin).—A number of genetical problems which have a direct bearing on practical plant breeding continue to receive attention. In the case of perennial rye-grass it has been found that dwarfism and its association with a certain type of chlorophyll deficiency is proving to be more intricate and more interesting than was at first suspected, and this is a problem which will receive further attention. The question of male-sterility in rye-grass is also under detailed investigation.

The inter-generic and inter-specific work with grasses is being continued, but progress is of necessity slow. By back crossing *Lolium* × *Festuca* hybrids to *Lolium* full male fertility has been regained in various generations, but, when this stage is reached, the plants are not usually very different from pure *Lolium*.

Of probable economic significance are the strains of *Phalaris* derived from the inter-specific cross *Ph. arundinacea* × *Ph. bulbosa*. It would seem likely that some of these strains will be far more vigorous than *Ph. bulbosa*, but less creeping, more winter green and perhaps less harsh than the *Ph. arundinacea*.

Good progress is also being made with the practical breeding in the case of the rye-grasses, timothy, the fine-leaved fescues and *Poa pratensis*, and promising strains of all these grasses (except the *Poa*) are now being subjected to small scale field trials (2, 3). The actual work of selection and breeding with economic ends in view is continuous and very laborious; thus in connection with the programme for 1931 no less than 19,000 single plants were set out for the above species alone. Most of the information collected on these plants is of interest only to the investigator himself.

Cocksfoot (Prof. R. G. Stapledon).—The work has now proceeded a long way towards stabilising (*a*) a good hay type ; (*b*) two good pasture types ; and (*c*) one good intermediate type ; all of these will be subjected to exhaustive field trials during the coming season.

Yorkshire fog (Mr. A. R. Beddows).—Certain lines having only a downiness of the leaf-sheath, while the leaf-blades are almost free from hairs, are under critical study, as are various forms which exhibit promising economic characteristics.

The broad-leaved fescues (Mr. Beddows).—Selections are being made in the direction of multi-tillered forms which also possess an ability for early spring growth.

Legumes (Mr. R. D. Williams).

Red clover.—Twelve new strains—all of the late-flowering type —which were planted out in 1930 in isolated areas for seed were harvested this year. Sufficient seed has been obtained from all these strains to carry out field trials next year.

Six new strains—wild, late and earlies—were also isolated this year for seed production next year, while a number of new strains which have been produced this year is to be planted for seed production next spring.

Several genetical problems were investigated, the most important being self-sterility and self-fertility, and cross incompatibility in inbred families; earliness of growth; longevity; chlorophyll deficiency; hairiness; flower and seed colour.

White clover.—Two new strains which were produced in 1930 were planted out for seed production. Some four new strains were produced in 1931 and these will be propagated for seed next year.

The economic significance of cyanogenesis in white clover is being intensively studied. A large number of tests was made on various samples of English wild white, Dutch, and New Zealand whites, as well as on wild forms from most of the European countries, from Australia and the United States of America, involving in all about 20,000 plants.

The modes of inheritance of various characters such as cyanogenesis, leaf size, flower colour, seed colour and leaf markings are being investigated.

Lucerne and Lotus spp.—The breeding work on these species is being continued (4, 5).

EMPIRE MARKETING FUND GRANT.

Seed production and isolation (Mr. Gwilym Evans).—During 1931 approximately 30 acres of pedigree grasses were harvested for seed, and 20 additional acres were sown. The pedigree strains were gown mainly in the Welshpool district and the Wye Valley, but several lots were scattered over a wide area in the Principality, with a view to testing the suitability of various districts for seed production of grasses. Demonstration plots of ½ acre (of cocksfoot and timothy) were established at two farm institutes (Pibwrlwyd, Carmarthen, and Pencoed, Glamorgan) in order to draw the attention of farmers to the method of growing pedigree grasses in drills for seed production.

Fourteen strains of pedigree red clovers were grown for seed in 1931. These were in the first stage of growing-on. The area of any one strain did not exceed ⅛th acre.

Investigations have been conducted relative to (*a*) the effect of various manures on the production of seed in the case of a number of strains of pedigree grasses; (*b*) the effect of time of application of manures on seed production; (*c*) the management of grasses for seed production; (*d*) the possibility of autumn sowings of grasses for seed production; (*e*) rate of sowing; and (*f*) the effect of harvesting at various stages of ripeness on the quality of the seed

(6, 7). Tests are also being conducted on an electrical method adapted for estimating the moisture content of grass seeds.

Up to the present practically all the seed of the pedigree strains harvested in Montgomeryshire and elsewhere has been used for experimental sward trials. During the session under review over 200 acres (chiefly, but not wholly, in Wales) have been sown in experiments of this sort. It is interesting to record that excellent reports on the behaviour of the pedigree cocksfoot have been received from the Highlands of Natal.

Arrangements are now under discussion with the Seed Trade Association of the United Kingdom for the growing-on and distribution of some of the most valuable of the strains so far produced by the Station.

Plant physiology (Mr. H. G. Chippindale).—All the physiological research is being conducted in relation to the grassland investigations. Definite problems which have come to light as the result of the field work are being taken up from the critical physiological point of view.

The occurrence of delayed establishment in some species of cultivated grasses has been under investigation for some time, and, as a result of the physiological studies now under review, is believed to be explained by the ability of their seedlings to persist for long periods in a latent condition and to develop normally afterwards. In this connection the effect on other grasses of competition with *Lolium italicum* has been studied more particularly. It is hoped to publish this work shortly.

Attempts to stimulate the germination of grass seeds by soaking the seeds in solutions of various chemicals have been unsuccessful. Seeds soaked in water and afterwards partially dried do, however, germinate earlier and give a higher total germination than untreated seeds, and these differences are sufficiently large to suggest the possibility of practical application.

Small scale and detailed experiments (in contra-distinction to the large scale experiments described in the report on the work of the Grassland Adviser, see p. 335) on the establishment of desirable grasses on acid hill-soils have been carried out. With thorough mechanical cultivation (in the case of these experiments effected by hand) in the absence of manurial treatment, the failure of such grasses is complete. Phosphatic manuring is essential to the establishment of grasses and clovers, and nitrogenous manuring almost equally so to that of the former. In the presence of both manures, satisfactory establishment has been obtained even with extreme soil acidity. Wild white clover and indigenous cocksfoot seem particularly suitable for upland conditions. The effect of different species of grass and of clover on the soil in which they are grown is being studied by pot experiments under greenhouse conditions, and in these researches Mr. R. O. Davies, of the Department of Agricultural Chemistry, is co-operating with Mr. Chippindale.

GRASSLAND AGRONOMY.

Important aspects of the work have been reported in connection with (*a*) the work of the Grassland Adviser (see p. 335) and (*b*) investigations on the improved management of grassland (see p. 337). Some further particulars of the investigation as a whole may be given here.

Trials with sheep (Mr. Ll. Iorwerth Jones).—The technique for employing tethered sheep has been greatly improved, and practically all the grazing trials are now being conducted by this means—during last season about 50 pairs of tethered sheep were employed and the number will be considerably increased this year. The influence of varying degrees of intensity of grazing on the botanical composition of swards of different types and on the establishment of seeds mixtures is under detailed study by this means, and results of great interest and significance are already being obtained. An interesting experiment has been in progress for two years comparing a pedigree (indigenous) strain of cocksfoot against a commercial strain, and also against indigenous perennial rye-grass and wild white clover. The results so far obtained would seem to suggest that on land suitable for perennial rye-grass this species has a decidedly higher feeding value than cocksfoot, while the high feeding value of wild white clover as such is made abundantly apparent.

An experiment of a similar type involving a large number of species and strains was also started last year, and this is a line of work that it is hoped greatly to extend and to continue on well conceived routine lines for a great number of years.

Seeds mixtures (Mr. W. E. J. Milton).—In addition to the extensive seeds mixture trials conducted in the counties (Mr. Thomas), a large amount of detailed work is still carried out at the Station. An important question under study is the competitive influences of different strains of the same species upon each other, and the extent to which the seasonal growth curve can be improved by blending strains rather than species. The indications are that the ideal mixture would be one consisting of few species, but comparatively many strains. The simple-pasture mixtures (consisting of indigenous strains), many of which are now in a fifth harvest year, continue to develop really excellent swards which are creating the greatest interest in all the districts where plots have been arranged.

A problem of the greatest importance in connection with seeds mixtures, especially when sown on newly broken land, is the competition that is set up by unsown species, and this is of course influenced by the degree of perenniality of both the sown and unsown species and to a large extent by the buried seed content (and the viability of such seed) of the fields on which mixtures are sown. Investigations have been started (by Mr. Chippindale and Mr. Milton) on this problem, and the buried seed content of a number of pasture types is being ascertained. This research is fundamental to any proper ecological understanding of grassland behaviour and the results so far obtained are sufficient to show that, when a really exhaustive survey has been made on these lines, supported of course by botanical analysis of the swards sampled, a great deal of light will be thrown on a number of pasture problems. This is a line of research that is being put on a routine basis and the necessary data will gradually be collected over a number of years.

Seedling establishment under different conditions (Mr. T. E. Jones). —In connection with the grassing-out of the hill country (see report on the work of the Grassland Adviser, p. 335) trials on seedling establishment are being conducted with a large number of species and strains of grass at different centres and with different manuring. We here have an extraordinarily interesting series of problems (see also section dealing with Plant Physiology), while the purely empirical results so far obtained are of great practical significance. Yorkshire fog has evidently a real capacity for quick establishment over a very wide range of soil types—the effect of manures on establishment is very marked and differential as between species and species. These are problems to which a great deal of attention is being given from a number of different angles and points of view.

Reports on strains of grasses and clovers.—Largely as the result of the Station's close contact with overseas workers (to a considerable extent an outcome of the appointment of Mr. William Davies as Overseas Grassland Investigator, rendered possible by a grant from the Empire Marketing Board) a large number of strains is received every year for growing-on and for critical report.

Mr. Davies brought back from New Zealand a number of such strains of perennial rye-grass and cocksfoot, and the results obtained with these have tended to confirm the interesting conclusions of Mr. Bruce Levy and Mr. Davies relative to the great differences that exist between the Hawke's Bay and Canterbury perennial rye-grasses. In all, 22 reports, involving some 200 samples, were sent out during the session under review; this is a service which is very much appreciated by our correspondents, both in this country and overseas, and incidentally provides the Station with valuable and interesting plant material.

Various services performed by the staff.—Members of staff have continued to inspect the clover crop for the Montgomery Clover Growers' Association. Mr. Williams inspected the late-flowering red clover trials set up in the English counties and reported on them to the Ministry.

Titles of papers issued during the year.

1. Jones, E. T.: New varieties of white winter oats. *Welsh J. Agric.* **8** 1932. (In the press).
2. Jenkin, T. J.: The method and technique of selection, breeding and strain-building in grasses. *Imp. Bur. of Plant Genet.: Herbage Plants. Bull. No.* 3, 1931.

3. Jenkin, T. J.: The breeding of herbage grasses. *Encyclopædia of Scientific Agric.* **1**, 1931. Baillière, Tindall and Cox, Lond.
4. Williams, R. D.: Methods and technique of breeding red clover, white clover and lucerne. *Imp. Bur. of Plant Genet.: Herbage Plants. Bull. No.* **3**, 1931.
5. ———: Breeding of herbage legumes. *Encyclopædia of Scientific Agric.* **1**, 1931. Baillière, Tindall and Cox, Lond.
6. Evans, Gwilym, and Calder, R. A.: Manuring pedigree grasses for seed production. *Welsh J. Agric.* **7**, 1931.
7. Evans, Gwilym: Seed production of pedigree grasses in Montgomeryshire. *Welsh J. Agric.* **7**, 1931.

7. SCOTTISH SOCIETY FOR RESEARCH IN PLANT BREEDING, EDINBURGH.

Cereals.

Oats.—The development of new types by hybridisation constitutes a large proportion of the work with this crop, and many unfixed hybrid plants were again grown in small plots. Several of the hybrid families bred from the Potato and the Sandy varieties contained promising material for selection. A few series of white-grained, early-ripening types selected from hybrids from the black-grained, early-ripening oat Orion were examined and compared for the purpose of obtaining a new group of productive, early-ripening types. Some of the most promising selections in these series appear to be breeding true, and they are being multiplied for further trial.

Additional genetical data were collected from a number of F_2 hybrids from crosses between black- and white-grained varieties. Several types of grey-grained plants have appeared in some of the progenies, and an attempt is being made to trace the origin of these and certain other aberrant forms

Twenty-three unnamed hybrid varieties, some of which had been included in previous years' trials and others which had reached the field-trial stage for the first time, were compared in quadruplicate plots with five standard named varieties. In these trials the dates of maturity and types of straw were noted, and the yields of grain were, as in previous years, subjected to statistical analysis.

In 1931 a few unnamed hybrid selections were tested in field trials in ten different districts of Scotland, ranging from Orkney in the north to Dumfries in the south. Reports on these trials will be received in due course.

Three unnamed fixed hybrid selections were submitted to the Department of Agriculture for Scotland for inclusion in the Cereal Registration Trials in 1931, and one of these has been recommended by the Oats Sub-committee for registration. This is an early-ripening variety which may take the place of the Sandy variety in certain areas of Scotland.

Wheat.—Further selections were made from the hybrids mentioned in the previous report. The aim of this work is to obtain productive, highly winter-hardy types.

Barley.—The work with barley has been slightly extended to include observations on a number of single-plant selections received from a member of the Society. These were grown for comparison along with the usual collection of named varieties. A few hybrid barleys were also grown, and a number of selections made for further trial.

POTATOES.

The experiments were continued with a view to obtaining by hybridisation new and improved varieties immune from wart disease and resistant to blight and virus diseases. Comparisons were again made of different hybrid families in order to find which pairs of varieties provided the most suitable combinations for the production of types maturing at the different periods recognised in agricultural practice.

Genetical data are being collected regarding the transmission of several botanical characters which have a bearing on the identification and selection of new varieties. In addition to the cultivated varieties of potato used for breeding, certain wild Solanums are also being utilised in the genetical investigations.

The stocks of varieties retained for breeding are carefully examined during the growing season each year for symptoms of virus diseases, and only varieties which appear healthy and vigorous are used as parents. Breeding from healthy parent plants continues to give encouraging results.

An endeavour is being made to obtain a collection of varieties which will breed true to type through the seed. A number of selected, previously self-fertilised seedlings were again self-fertilised in 1930 and their seedling progenies compared in 1931. In some of these progenies the stage is now being approached when they can be regarded as breeding true for the main characters of economic importance.

Healthy plants of all the promising seedling selections were grown and compared with standard varieties. A few of these which had given encouraging results in previous years' trials were grown in considerable quantity to provide tubers for more extensive trials, if required, in 1932.

The work referred to above was undertaken at the Society's sub-station at Ainville, Kirknewton. At the Plant Breeding Station, Corstorphine, a large number of seedlings were grown in small trial-plots to obtain additional comparative data as regards yield of tubers, habit of growth and prevalence of blight and virus diseases. Four seedlings which had shown a high standard of excellence in the preliminary trials at the Plant Breeding Station were sent in 1931 to the Department of Agriculture for Scotland for inclusion in their Registration Trials.

Herbage Plants.

The investigations devised to obtain precise information concerning the nature of sub-specific units have been continued with the object of determining the grouping of natural units in relation to their geographical position, and to the ecological factors of their habitats. The sea plantain has been extensively employed in these experiments. Populations of this species group have been obtained from various habitats in Britain, Continental Europe (including Arctic Europe), Faroe Islands, Iceland, Greenland, Canada, and the U.S.A. A somewhat parallel series of Alpine timothy is being simultaneously studied.

The study of *Phleum pratense* L and *P. alpinum* L has resulted in the lumping of these two Linnean species, and the separation of two intersterile groups within the *P. pratense* L. section (2). This latter division is of much agricultural importance, partly on account of the fact that each group is suited to a different environment, and partly because the intersterility will maintain the identity of each group during the processes of multiplication. The units of the species have now been classified as follows :—

Coenospecies	*Phleum pratense-alpinum*
Ecospecies	*P. pratense diploidium.*
	P. pratense hexaploidium.
	P. alpinum diploidium.
	P. alpinum tetraploidium
Ecotypes	*P. pratense* 2*n* *prostratum.*
	P. pratense 2*n* *decumbens.*
	P. pratense 2*n* *ascendens.*
	P. pratense 2*n* *erectum.*
	P. pratense 6*n* *decumbens.*
	P. pratense 6*n* *ascendens.*
	P. pratense 6*n* *erectum.*

Three strains of pasture grasses have now reached their third year of multiplication. These comprise one strain of timothy (*P. pratense diploidium*), one of perennial ryegrass and one of cocksfoot. It is proposed to multiply another strain of *P. pratense diploidium* next season.

Swedes and Turnips.

Investigations of breeding methods were continued, especially with regard to the production of true-breeding strains of swede by continued selection and self-fertilisation under artificial isolation. Lines originating from commercial varieties were maintained and new additions made, but a larger proportion of the new selections was taken from the segregating generations of artificial crosses (1).

The disease-resisting properties of certain lines of turnip were compared with those of the " Bruce " and with non-resistant strains. Various forms of " bulbless bolters " were examined by progeny observations and were judged to have been either Swede-like rape sp. or F_1 hybrid swede × rape, or in one case possibly swede × rape back-crossed on swede. Comparisons were made with material of these types artificially prepared.

Yield-trial technique, embracing determinations of dry-matter, soluble solids, sugar and weight, was employed for appraising the feeding values of certain inbred lines ; while bulb-to-bulb analysis showing dry-matter, soluble solids, and weight of bulb was used for the selection of seed parents from certain F_2 populations. Two of the yield trials were concerned with the joint investigation into the value of the soluble solids test which has been proceeding since 1927 in co-operation with the Chemistry Department of the Edinburgh and East of Scotland College of Agriculture.

Those strains not embodied in yield trials were closely observed in duplicated plots with commercial varieties as controls. Lack of sensibility to bolting was tested in certain lines by use of early and normally sown plots.

POTATOES (EMPIRE MARKETING FUND GRANT).

Plant Breeding Station, Corstorphine.—The work at this station has been principally concerned with a physiological investigation of leaf-roll in two varieties, Arran Victory and President. The aim of the work was to establish the nature, if any, of the differences in carbohydrate, nitrogen and ash metabolism in healthy and diseased plants. Healthy stocks of tubers were obtained from the Department of Agriculture for Scotland, Plant Registration Station, Corstorphine, and the disease was transmitted by the aphid *Myzus persicae,* which proved highly efficient in this respect. The material for the physiological work was gathered at different times in the growing season over a daily period of nineteen hours. Up to the present only the carbohydrate side of the estimations has been completed, and the results are being statistically examined. It is hoped that in that way relations will be established with regard to the rate of formation of sugars as well as rates of translocation and the nature of the products of translocation in healthy and diseased plants. These results will be shortly available. The nitrogen and ash material has been collected and awaits analysis.

The physiological side of the virus work was carried out in the special insect-proof greenhouses. A preliminary series of field experiments was also started on a small scale to determine the method and rate of spread of a number of different virus diseases. The results in this case will not be available till the following growing season.

Ainville sub-station.—The work principally carried out at Ainville was stock raising for next year's diseased material, when it is hoped that a similar physiological survey will be made on the crinkle, paracrinkle and mosaic diseases of the potato.

North of Scotland sub-station at Gibston, Huntly, Aberdeenshire.—Investigations into virus diseases at the North of Scotland sub-station, Gibston, Huntly, are being confined to a study of the mosaic diseases of potatoes.

Varietal differences in the expression of visible symptoms due to the presence of a mosaic virus from a single source were examined by means of grafts and inoculations between varieties of *Solanum tuberosum* and seven species of solanaceous plants. *Hyoscyamus niger* was found to be of value in discriminating between mosaics and also in determining the presence of viruses of the mosaic and necrotic types latent in apparently healthy plants.

Preliminary data, obtained in 1930, pointing to a significant difference between the hydrogen ion concentrations in healthy and mosaic infected plants were confirmed. Sap expressed from diseased plants was found to be slightly more acid than sap expressed from corresponding parts of healthy plants.

A study of the carbohydrate metabolism of healthy and mosaic infected plants is in progress.

Further data were obtained on the relation between virus diseases in parent plants and the health of progenies. This investigation is to be continued with seed obtained during the year.

In conjunction with the investigations in progress at the Ainville sub-station, seedlings were raised for the purpose of obtaining genetical data on botanical characteristics and selecting plants of a possible economic type.

Titles of papers issued during the year.

1. DAVEY, V. McM.: Colour inheritance in swedes and turnips and its bearing on the identification ot commercial stocks. *Scott. J. Agric.*, **14**, 3, 1931.
2. GREGOR, J. W.: Experimental delimitation of species. *New Phytologist*, **30**, 3, 1931.
3. ROBB, WM.: *Annual report for the year ended* 31*st March*, 1931.

8. PLANT BREEDING DIVISION, MINISTRY OF AGRICULTURE, NORTHERN IRELAND.

Oats.—Work continues upon the improvement of existing varieties by the gradual substitution of pure line strains for existing mixed stocks of local varieties. Such strains as have been distributed are generally recognised to be superior and there is a demand for supplies of them. Of the two completely new types which have recently been tested in large scale trials, one, the stiff-strawed type, has, proved very successful—the variety is now being distributed under the name Stormont Arrow. Trials of the other early-maturing type were unsatisfactory. When all the varieties were sown at the same time, its earliness entailed upon the variety damage by birds and over ripeness to such an extent that comparative yield results were worthless. A few trials in which this variety has been sown a fortnight after the others indicate that it may be very useful in districts where fit sowing conditions are not obtained until abnormally late in the season.

Flax.—Two new varieties have been tested on a large scale for two seasons with distinctly promising results. Seed stocks of these varieties, Stormont Gossamer and Stormont Cirrus, are being raised.

9. NATIONAL INSTITUTE OF AGRICULTURAL BOTANY, CAMBRIDGE.

Crop Improvement Branch.

Yield and quality trials and observation plots.—The number of new varieties introduced by State and private plant-breeders increases so rapidly that it is impossible for the field scale trials to keep abreast of the material, and though observation plots test many features of importance they cannot measure accurately the chief factor—yield. Ways round the difficulty are always being sought and this year two chess-board trials of wheats and one of winter oats were undertaken at Cambridge ; temporary cages were erected to protect the plots from birds after sowing and at harvest time ; some useful information was obtained about the larger yield differences between the varieties included in the trials, but the calamitous summer robbed this venture of a fair chance. The results were, however, promising enough to show that under normal conditions such trials combined with observation plots can be of real help in deciding which of the many varieties awaiting test merit a trial on the full field scale. Further study is being given to the development of this method.

The conditions under which the trials are conducted have been improved by taking 22½ acres adjoining the existing trial ground at Cambridge on a 14-years lease in order to reduce the area of crops grown on contract, and by perfecting the seed cleaning plant.

The varieties in field trials in 1930–31 were :—

Winter wheat.—Squarehead's Master, Steel, Iron III (these three both normally and intensively manured), Chevalier, Renown, Starling II, Little Joss (two stocks), Victor, Wilhelmina, Rivett, Yeoman II, three new varieties from the Cambridge Plant Breeding Institute and two from private breeders.

Winter oats.—English and French stocks of Grey Winter.

Winter barley.—Carter's six-row, Plumage-Archer 1924, and three new varieties from the Cambridge Plant Breeding Institute.

"*January*" *wheat.*—A.1 and a new variety from the Cambridge Plant Breeding Institute.

Spring wheat.—A.1, Red Marvel, April Bearded and two new varieties from the Cambridge Plant Breeding Institute.

Spring oats.—Abundance, Thousand Dollar (these two both normally and intensively manured), Golden Rain II, Star, Marvellous Glasnevin Sonas, and Progress.

Spring barley.—Plumage-Archer 1924, Spratt-Archer (these two both normally and intensively manured), two new varieties from the Cambridge Plant Breeding Institute and one from Dr. Beaven.

Mangolds.—The same five Intermediate types as were in the 1930 trials, and six of the seven Globe types, Carter's Golden Standwell being omitted.

Swedes.—The same four types as in 1930 with the addition of Purdy's Purple Top.

Sugar beet.—The same three sets of trials as in 1930.

Lucerne.—Strains of Provence, English, Grimm's, Hungarian, Marlborough, Hunter River and Medanose.

Peas.—Dun (six stocks), Harrison's Glory (three stocks), Prussian Blue, Black-eyed Susan, Koopman's Glory, Hijlkema's Unica, and seven new varieties from the Cambridge Plant Breeding Institute.

Lucerne trials have been laid down at new centres for the first time, with a view to popularizing this valuable crop, and they are now in progress in Norfolk, Essex and Shropshire. Other features of interest are the increase in the number of trials of peas and the appearance of "January" and spring wheats for the first time in trials. The range of the observation plots, which serve as a filter for new material and demonstrate the best established varieties, was as wide as ever, more than a hundred varieties of different crops being grown. The important series of sugar beet plots designed to show what differential response to the date of lifting there is between varieties was repeated for a second year, and it is hoped to bring this investigation to a successful conclusion in 1932. Some experimental types grown in the Fens may in due course give that district sugar beet better adapted to its needs than anything yet available. Crops at present dealt with by observation plots only are kales, now being grown at Cannington and Cambridge, sainfoin, which has been established at Long Sutton, and grasses and clovers, the plots of which at Cambridge are furnishing experience in the technique required for trials. Work confined to Cambridge consisted of the reference collection of cereals, synonym plots, and stock plots of cereals and peas to provide uniform seed for future trials or in a few cases for marketing. There were nearly a hundred of these stock plots, ranging in size from $\frac{1}{20}$th to 3 acres, most being between $\frac{1}{4}$ and $\frac{1}{2}$ acre.

It was very interesting to see that the often-expressed fears of the ability of " E " type sugar beet seed to maintain a good sugar content in a wet and sunless season proved to be without foundation. Kirsche's Ideal mangold has fully maintained its earlier promise. Among cereals Starling II wheat is doing well in Hampshire, and Golden Rain II and Star oats have proved their claims to be worthy companions of Victory and Golden Rain I.

Everyone sees the value of the discovery of an improved variety, but the trials are rendering equally useful service to farmers by keeping bad ones off the market. This negative but essential task is continually carried on and a particularly good example of it can be quoted from the past year's work. Incidentally it shows the value of observation plots repeated at several centres as a means of sifting the good from the bad before the stage of elaborate trials is reached. Two wheats, Red Drottning and White Drottning, bred at Svalof, were submitted to the Institute for observations by the English agents. The unanimous report of Recorders was that these varieties were in no respect an improvement on those already on the English market and that they showed an unusual susceptibility to yellow rust. This susceptibility did not occur in Sweden but it was confirmed in Holland. Svalof accepted the results and withdrew both varieties from England.

The reports of the work of the 1930–31 season will appear in forthcoming numbers of the Journal. Papers Nos. 3–6 and 10–14 refer to some of the work done with these crops in previous years.

The Institute continues to receive invaluable assistance in determining the quality of the produce of the trials from the Cambridge School of Agriculture the National Association of British and Irish Millers and the Institute of Brewing.

Co-operation with plant breeders.—The close relations with the Cambridge University Plant Breeding Institute and the Welsh Plant Breeding Station have been satisfactorily developed during the year. The absence of a Welsh sub-station puts a limit to the possibilities in the case of the latter, but an earnest of the goodwill is the inclusion in the Institute's trials of two white winter oats and one spring oat which may be of value in England. Winter oats is a crop where the chances of offering agriculture a valuable new variety are particularly good, for besides the two Welsh oats, three from the Cambridge Institute and one from Messrs. Gartons, Ltd., are now in trials. Other varieties of promise are wheats from Cambridge, one of which may yield heavily, another stands well enough to resist lodging even in 1931 and on Fen soils, and a third seems to combine good field characteristics with superlative quality. The spring oats received from the same source include material which within measurable time should add one or more heavy-yielding stiff-strawed varieties to the range of the farmer's choice.

Wheats designed for sowing in January after sugar beet have been a disappointment, but two spring wheats are under trial and there is a wealth of spring barleys and peas. The Institute is also growing seed for the Scottish Society for Research in Plant Breeding, is in touch with all responsible private breeders and is testing varieties for three of them.

Co-operation with other organizations.—The outstanding event of the year in the crop improvement work has been the successful launching of the first co-operative scheme of variety trials to cover the whole of England and Wales. As the result of organising activities in the preceding year trials of three varieties of spring oats, Victory, Marvellous and Golden Rain II, were grown at 107 centres spread over 46 counties, all the seed of each variety coming from a single bulk. At many centres duplicate or triplicate plots were grown, and other varieties added. Abundance was included very generally, and the Welsh centres by agreement with one another all grew Record. For this result full acknowledgment must be made of the enthusiastic response from Agricultural Colleges and Institutes and the County Agricultural Organizers, and the sympathetic attitude of the Provincial Advisory Conferences. Crops of the three chosen varieties were grown by the Institute near Cambridge to provide seed for continuing the trials in 1932.

Encouraged by the reception of the spring oat trial proposals, the Institute tested the demand for wheat trials with the idea of growing the seed with which to begin the actual work in the autumn of 1932. There was no doubt about the demand, but the axe fell and the scheme has had to be postponed to more propitious times.

Seed growing.—Thousand Dollar and Abundance oats were sold to the trade in the spring of 1931, and about 90 and 45 quarters respectively of Little Joss wheat and Grey Winter oats in the autumn. Experience has shown the need for this enterprise; the demand from seed and corn merchants has proved to be very satisfactory, and the seed goes to most parts of the country. The answers to an enquiry about the need for helminthosporium-free seed of barley, and reports of the impurities in existing stocks, have led the Institute to arrange to offer about 100 quarters of Spratt-Archer for the spring of 1933; there will also be a small stock of Little Joss for sale next autumn.

OFFICIAL SEED TESTING STATION.

26,862 samples were received in the season ended 31st July, 1931. Another 3,080 samples were tested for purposes of investigation; the total tested was thus 29,942. This has only once been exceeded and is only 51 less than the record total of 29,993 tested in 1927–28. The number of routine samples, 26,862, is in fact the highest in the history of the Station, the previous best being 26,583 in 1927–28. The experiments previously carried out with softened water have led during the past year to the installation of a water-softening plant of the base-exchange type with a synthetic mineral filling. This is working satisfactorily and will not only save labour, gas and electric current but also prolong the lives of the Copenhagen tanks. Another improvement arising from the study of delayed germination and methods devised at the Station to overcome this difficulty is the installation of a cold storage incubator. This was ready for use at the end of 1931 ; it will make the testing of slow-germinating cereals as well as of certain other seeds very much easier.

The scale of fees charged by the Station has been under consideration during the year. It was impossible to introduce any general reductions, but some adjustments are being made experimentally this season and it is hoped that they will be found useful both by the small man and by the merchants who regularly send large numbers of samples.

The Chief Officer has been appointed a member of the Wild White Clover Growing-On Committee and Mr. Brett acts as Secretary to it. The 571 plots sown with seed from the samples of heads collected by the Ministry's inspectors in 1930 were kept under close observation throughout the season, and they were examined and reported on by the Committee in June and August. The bad weather of the past summer hampered further progress ; nevertheless 167 samples of heads were sent in to the Station by the Ministry's inspectors and 158 of them were successfully sown in September. A good deal of work has been done with red clover with a view to detecting any foreign or blended seed which might possibly be offered as English. Impurities found in cereals of foreign origin have been another subject for study, and many species of seeds found as impurities in commercial samples are being grown for identification. The work on delayed germination is being continued, and abnormal and defective growths require constant study ; the various species of Brassica have received particular attention from this point of view in the past year. Information continues to be accumulated about loss of vitality, and the chance offered by the bad harvest of 1930 was taken to study this in the case of weathered seed. Work has also been done in the field and laboratory on commercial species of *Festuca* and *Agrostis*, and among seed-borne diseases special attention has been paid to *Helminthosporium* in barley and oats, and the effect on this of the fungicidal dusts which are now being used in increasing quantities.

The International Congress at Wageningen in July, 1931, was attended by the Chief Officer. Apart from the technical papers the principal business was the discussion and formulation of seed testing rules and certificates for international trading. They have been referred to the International Seed Dealers' Association which meets in Berlin in 1932. They will in any case be optional. The Chief Officer was re-elected a member of the Executive Committee of the International Seed Testing Association.

Potato Trials.

Yield and maturity trials.—One of the principal trials this year at Ormskirk was designed to review the field technique. Five varieties—Ally, Majestic, Arran Banner, King George and International Kidney—were tested by the formal method which has been used by the Institute with success for many years, and on an adjoining piece of land the same five varieties were tested in two Latin squares to a plan provided by Dr. R. A. Fisher of Rothamsted. Dr. Fisher is kindly collaborating in the study of the results. Another new feature of the trials was that they were sprayed as protection against blight. This well-established practice has not hitherto been followed at Ormskirk as it was thought that it would prevent observations being made satisfactorily on the foliage. Unchecked blight, however, has wrought such havoc in recent years that it has rarely been possible to determine differences of maturity, so that resort to spraying became a case of Hobson's choice. The effects of the disease on the 1931 crop were disastrous, and, though the Ormskirk trials were sprayed four times, the haulms could not be saved. It was thus all the more encouraging to find that some small plots sprayed once with a new material sent for experimental purposes to Ormskirk remained green until they matured naturally. The Institute retains for the present an open mind, but it proposes to study this material very thoroughly next season ; if its present promise is fulfilled, it will not only solve one of the difficulties hitherto experienced in potato trials but will also confer a great benefit on the commercial potato grower.

Another of the Institute's aims is to find new sources from which the growers can obtain healthy seed tubers, and in particular to explore the possibilities of likely English districts. Stocks of Great Scot from Scotland, Irish Free State, Cumberland, Yorkshire and Wales were therefore tried against each other at Ormskirk, and another trial was carried out with stocks of Arran Banner from the same districts, Lincolnshire being substituted for Wales. Four other trials were undertaken at Ormskirk and three at Kirton. A Lord Derby Gold Medal was awarded to Arran Pilot, considered by many to be the best immune first early yet introduced.

This year the regularity and vigour of the Ormskirk trials were better than ever ; this is partly accounted for by the steady improvement in the quality of seed potatoes which has been a noticeable feature in recent years. This improvement has certainly been encouraged by the attention which the work of the Institute and kindred organizations has focussed on the importance of choosing good varieties and using for planting only sound tubers from healthy crops.

Quality trials.—The collaboration with Dr. L. H. Lampitt, Director of the research laboratories of Messrs. J. Lyons & Co., Ltd., in testing the quality of potatoes, provided such interesting results in 1930 that during the past season Ninetyfold, Golden

Wonder, King Edward and Majestic were grown at six centres representative of the principal potato growing districts in order to see whether there is differential response to environment so far as quality is concerned. Dr. Lampitt is also testing the quality of promising new varieties from the ordinary trials.

The official immunity trials at Ormskirk.—Wart disease was so abundant in 1931 that it is reasonable to assume that any variety which escaped infection this year would never develop wart disease in the field. There were 46 seedlings entered for the first year, and 30 for the second. 19 stocks came in accordance with the usual arrangements from the official testing stations in Scotland and Northern Ireland. Controls and key plots numbered 46, making a total for the immunity trials of 141. All but two of the distinct varieties were free from wart disease in the field. The whole of the first and second year entries, and the stocks from Scotland and N. Ireland, were also tested indoors by the contact method developed at Ormskirk on the basis of Miss Glynne's original work. Similar tests were made by the Department of Agriculture for Scotland. Most of the seedlings were also tested by growing in a wart compost in pots at Ormskirk. Tubers of seedlings showing incipient infections were sent to Miss Glynne at Rothamsted for microscopic examinations. In most cases there was a satisfactory agreement between the results from the several tests, but there is no doubt that the contact method is more severe than the field. A few varieties consequently show wart in the indoor test though they remain free in the field, and until these cases have been explained the exact relationship of the indoor and field tests cannot be settled. The co-operation which has now been established between the Scottish Department, Rothamsted and Ormskirk, under the supervision of the Interdepartmental Committee, ensures that no effort will be spared to solve this interesting problem.

The wart disease work was rounded off by the susceptibility trials for seedlings, of which there were 22, and demonstration plots of new immune varieties listed by the Ministry of Agriculture in 1930. There was also the usual reference collection of potato varieties, consisting of 99 plots. Mr. Wm. W. Findlay, of Marischal College, Aberdeen, generously gave 82 of these stocks.

Potato synonyms.—The Committee are able to record the lowest number of synonyms of any year since the Ormskirk trials began. Only 6 per cent. of the first and second year entries were found to be synonymous, a very different tale to the 72 per cent. found in 1920. Moreover the Committee were able to come to their decisions with only one meeting and thus saved the time and expense involved by the second visit to Ormskirk which hitherto has always been necessary.

In order that growers may have every help in knowing what they are buying, the Institute now issues each winter a list of the stocks offered for sale in the current catalogues under synonymous names. These stocks are also grown at the Potato Testing Station side by side with the original varieties. It is an instructive collection and attracts each year much attention.

Virus disease.—Collaboration has been continued with Dr. F. T. Bennett of Armstrong College and Dr. Salaman in studying the effect of environment on the development of virus disease. Great Scot and Arran Banner were the varieties chosen and stocks were collected from Scotland, Wales, Cumberland, Lincolnshire and Dr. Salaman. They were sprouted at Cambridge and each tuber was divided into three sets. One set from each was planted at Penrith, Ormskirk and Cambridge. The results are being considered by Dr. Salaman.

At Ormskirk another trial was carried out with two stocks of Arran Consul to see how far leaf-roll depresses yield. The selection of healthy seed tubers from a diseased stock of Arran Consul and of seed tubers of Majestic lifted immature has been continued.

Titles of papers issued during the year.

1. *Eleventh Annual Report.*
2. Parker, W. H.: The methods employed in variety trials by the National Institute of Agricultural Botany. *J.N.I.A.B.*, **2**, 4, 1930.
3. Armstrong, S. F.: Sugar beet variety trials, 1927-29. *Ibid.*, **2**, 4, 1930.
4. Parker, W. H.: Trials of types of swedes, 1926-28. *Ibid.*, **2**, 4, 1930
5. ———: Trials of types of mangolds, 1926-28. *Ibid.*, **2**, 4, 1930.
6. ———: Mangold variety trials, 1929. *Ibid.*, **2**, 4, 1930.
7. Eastham, A.: Twelfth annual report of the O.S.T.S. for England and Wales (1928-29). *Ibid.*, **2**, 4, 1930.
8. Keeble, Sir Frederick. Development of the Institute's activities. *Ibid.*, **2**, 4, 1930.
9. Parker, W. H.: Co-operation in crop improvement. *Ibid.*, **2**, 4, 1930.

Farmers' Leaflets.

10. No. 1. (and supplement). Varieties of cereals for autumn sowing.
11. No. 2. Varieties of cereals for spring sowing.
12. No. 3. Varieties of potatoes.
13. No. 4. Lucerne.
14. No. 5. Strains of sugar beet.

10. PLANT REGISTRATION STATION, DEPARTMENT OF AGRICULTURE FOR SCOTLAND.

Potatoes.

Laboratory tests for immunity from wart disease.—In 1931 1,429 varieties were subjected to test and 213 found to be susceptible.

Intensive tests of infectivity by the contact inoculation method were applied to 35 new seedling varieties which were believed to be immune under conditions of natural infection in the field. These represented varieties under final official test of immunity in England and Northern Ireland as well as those undergoing similar test in Scotland. Two subsequently proved to be susceptible in the field. Of the remainder 15 contracted incipient infections in the laboratory but exhibited no sign of susceptibility in the field.

Registration scheme.—Seventeen varieties were submitted to test with a view to subsequent registration. Two of these varieties passed into extended test in 1932. Three varieties in their second year of test were not recommended for further trial. Five varieties in extended third year's trial received adverse reports and were not admitted to registration.

The varieties which have now been registered by the Department as good immune varieties are Arran Consul, Herald, Arran Banner, Arran Crest, Arran Pilot.

Virus diseases scheme.—Of the selection of Majestic made in 1926 a four-acre plot was available in 1931. This stock was unique in remaining free from mottling. It received a stock seed certificate. Of the units selected in 1928, 11 built up stocks are available, the number of varieties being 8. Of the units selected in 1929, 597 units representing 46 stocks and 11 varieties will be bulked in 1932. Of the units selected in 1930, 510 units representing 40 stocks and 14 varieties are being retained for further isolation. In 1931, 1,741 new selections were made from 65 stocks, the number of varieties being 18. The total number of farmers now engaged on the work is 76. The total number of stocks built up or in different stages of propagation is 163, representing 22 varieties.

One tuber of each new selection is planted on early ground at Joppa for diagnosis before the field inspections commence. Work in the insect-proof greenhouse is confined entirely to the elucidation of symptoms of different types of mosaic and symptoms resembling mosaic which have appeared in the selected units and in seedlings undergoing test for registration.

Skin spot investigation.—An investigation into this disease with special reference to its effect on seed tubers is proceeding.

OATS.

The four new varieties which were under trial in 1930 were submitted to further trial in duplicate half-acre plots in 1931. One variety, which has been named " Bell " oat, has been admitted to registration, having been recommended as a variety specially suitable for cultivation on poor soils and in late districts. Two varieties have been recommended for extended trial in 1932.

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11. CROP (AND ANIMAL HUSBANDRY) DIVISION, MINISTRY OF AGRICULTURE FOR NORTHERN IRELAND.

Potatoes.—Two experiments have been carried out, in 1929 and 1930, to determine the effect of the size of the seed tuber planted on the relative proportion of ware, seed and chats in the resultant crop. Three sizes of seed tubers were planted, normal size sets, obtained by riddling through a 2″ and over $1\frac{1}{4}$″ riddle, while a quantity of ware potatoes was dressed with 3″ and $2\frac{1}{2}$″ riddles into larger and smaller sizes. The experiments showed (1) that larger sets gave a heavier total crop, in which there is a higher proportion of the smaller sizes of tubers, than did smaller sets.

Grassland.—An experiment was commenced in 1929 to afford an answer to some of the problems concerned in the improvement of grassland. Five plots, each 2 acres in extent, were fenced off individually in a field and an area of 4-5 acres left as an observation control. Plots 1, 2 and 3 received a thorough and effective harrowing and all the dead material was collected and carted off. Plot 1 received a complete manurial dressing of nitrogen, phosphates and potash ; Plot 2, phosphates and potash only ; and Plot 3, phosphates only. Plots 4 and 5 were ploughed up in the spring of 1930, and Plot 4 drilled with oats. No cover crop was sown in Plot 5 and a seeds mixture of mainly indigenous species was sown in April, 1930, in Plots 4 and 5. A complete manurial dressing of nitrogen, phosphates and potash was given to Plots 4 and 5.

Each plot is treated as an individual unit and stock turned on to it as soon as it is ready for grazing. When the grass on the plot in question is eaten down the stock are removed, the plot rested, and grazed again when the grass is sufficiently grown. An accurate record is kept of the dates on which individual plots were grazed and also of the number and class of stock.

Botanical and chemical analyses are also being carried out by the Botanical and Chemical Divisions respectively.

Reclamation of bog.—An area of 30 acres of a bog previously cut for peat, but now used up, has been reclaimed, and during the past two years has grown a heavy crop of excellent potatoes which have been sold for " seed " purposes. A record of the operations necessary in this reclamation and their cost is being accumulated, and experiments in manuring the crop have also been carried out (see p. 22).

Cost accounts.—Full and detailed cost accounts are kept of all the farm operations at the Research Farm at Hillsborough. Data from three full years have now been accumulated. As before, the accounts have been abstracted to obtain costs of various operations and have provided general figures for use in the management of the farm and for the completion, by adding the financial aspect, of much of the experimental work being carried out.

Title of paper issued during the year.

1. Rae, R. and Hale, R. W. : The effect of the size of set on the resulting potato crop. *J. Min. Agric. N. Ireland.* 3. 137, 1931.

C.

HORTICULTURE
and
GLASSHOUSE CROPS.

12. LONG ASHTON FRUIT RESEARCH STATION, BRISTOL UNIVERSITY.

FRUIT CULTURE.

I. Plant Nutrition. (1)

(*a*) *Rootstock problems.*

Field experiments.—The trial plots at Long Ashton of bush and standard apple trees on vegetative stocks originally raised from seedlings at the Station (2) are now reaching the stage when the first results of the stock effects can be observed.

Two of the rootstocks show a considerable degree of incompatibility with the varieties Lane's Prince Albert, Worcester Pearmain and James Grieve, though Newton Wonder and Blenheim Orange are growing well on these stocks.

In the cases of other stocks, differences in their effect on vigour of growth, quantity of blossom and amount of fruit borne are evident.

Data from the supplementary trial stock plots in Gloucestershire, Somerset and Worcestershire were obtained and several additional trials have been commenced or arranged in Devon, Gloucestershire and Worcestershire.

The County stock plots include one of Bramley's Seedling on seedling stocks from Hampshire Crab.

Records continue to be taken of the trees on the plot devoted to trials of the Malling rootstock types. The data collected up to 1929, when the cultural system was changed, are undergoing analysis. Detailed recording is now confined to the variety Worcester Pearmain, only more general records being taken on Lanes and Bramleys.

A proportion of the Bramley trees will be removed from the plot during the coming winter as the trees have become overcrowded.

Several features of interest are now in evidence in the plum rootstock plot. This plot was planted with the object of determining the suitability of various rootstocks for several varieties under west country conditions, and for examining the incidence of "die-back" in relation to rootstocks and varieties.

Data relating to growth, mortality, etc., indicate that Myrobolan B and Yellow Pershore are among the most suitable stocks, whilst common plum and St. Julien are among the least satisfactory.

Laboratory work.—The investigations relating to the interrelationships between rootstock effect and manurial treatments referred to later in Section I (*c*) (p. 60) have been extended to embrace the effects of rootstocks under various environments. Chemical studies have been commenced on the apple rootstock plot at Long Ashton Station. In the initial stages the determinations have been confined to nitrogen, dry matter and ash constituents in terminal shoots, and nitrogen, ash constituents, acidity and sugars in fruits. The chemical data will be examined in conjunction with pomological data relating to growth and cropping features.

(*b*) *Factors determining the relation of growth and fruit bud formation.*

The respective activities of root, shoot and leaf are closely concerned with the process of fruit bud formation. The following sections have direct bearing on this subject.

Stock and scion relationship (3).—The effect exerted by certain scion varieties upon root character is under examination in an experiment in which bench grafted trees are being used. The effects will be determined with regard to tree uniformity and root morphology and anatomy.

An experiment is in progress to discover whether any stimulating effect on the growth of a scion variety, due to rootstock influence, can be observed. The scion variety used is Malling No. IX, and the rootstocks, Malling Nos. II, IX, XII and miscellaneous seedlings. The nursery phase of the experiment will be completed this winter. The work will be continued under plantation conditions, the nursery trees being headworked with a uniform scion variety.

The nature and location of rootstock influence are questions of fundamental importance. Experiments are in progress to determine whether rootstock influence is mainly due to the " stem piece " or to the absorbing root system. Worcester Pearmain is utilised as the scion variety, being double-worked on seedling roots, with Malling Nos. IX, II and XIII forming the respective intermediate " stem piece " portions.

It is thought that the different properties of rootstocks may be associated with differences in bark and sap composition. Preliminary examinations of bark and sap of certain rootstocks have been made and the results indicate that this line of attack merits further study.

The influence of the top bud on the growth of the scion.—The data obtained in 1930 have been published in the Annual Report of the Research Station for 1930 (4). It was found that, where the top bud of the scion was directly in line with the callus union, there was a better take of grafts, 84 per cent. as against 75 per cent. in the case of Bramley's Seedling. The bud in line position also gave a more uniform stand of trees, an increased number of large trees and a decreased number of small trees. These trees are still under observation and further records will be taken in the winter of 1931.

The annual shoot growth curve of apples.—This work which was in abeyance during 1930 has been resumed in connection with the chemical studies on the stock plot noted in Section I (*a*) (p. 57). Weekly shoot measurements were taken of selected shoots of Worcester Pearmain and Lane's Prince Albert on several rootstocks.

The relation between leaf area, internode length and fruit bud formation.—A detailed investigation into the effect of several rootstocks upon the leaf area and internode length of the shoots of apples has been carried out.

There is a close correlation on all stocks between leaf size and length of the internode immediately below each leaf. On No. IX rootstock internodes were relatively short and the leaves slightly smaller. The stock effect, however, does not destroy the correlation mentioned above. The distribution of long internodes along a shoot is affected by rootstock.

The normal seasonal physiology of fruit trees.—The observations on the periodicity of the root growth of two types of apple root stocks, begun in 1930, are being continued.

Biennial bearing of apples.—The effect of fruit thinning on biennial bearing is being investigated, using the apple variety Early Victoria. Five trees are under each of the following treatments :—(*a*) blossom trusses thinned by 50 per cent. at blossom time ; (*b*) fruits thinned to one fruit per cluster immediately after petal fall ; (*c*) fruits thinned when the largest fruits are ready for early market ; (*d*) control—all fruits allowed to stay on tree until picking time. The results so far indicate that blossom thinning has exerted the greatest effect upon biennial bearing. It has given slightly fewer apples but has induced a regular crop each year. The control trees persist as biennial bearers. (See also Section I (*c*) (p. 60).)

Bark ringing (5).—Records of crops continue to be taken of Bramley's Seedling trees in connection with bark ringing treatments. In all cases a complete ring round the main stem has induced bearing in vigorous unfruitful trees. The practice of bark ringing, even when a complete ring is made round the main stem, is devoid of risks if the ring is made towards the end of May and is covered *immediately* with a suitable waterproof covering such as insulating tape.

Further storage experiments with Bramley have verified the conclusion that fruits from ringed trees, in the season of the ringing operation, are susceptible to low temperature internal breakdown and to superficial scald (6). Results on bitter pit have been variable.

Tree shaping and pruning.—The experiment on tree shaping has been continued. The varieties Early Victoria, Cox's Orange Pippin Allington Pippin and Worcester Pearmain are more easily shaped, to various patterns than the varieties King Edward VII, Blenheim Orange and Beauty of Bath.

The modified leader system of pruning shows promise of inducing early cropping.

Further evidence of the differential effects of the systems of "spur pruning" and "regulated" pruning on the storage qualities of fruits has been obtained, and supports the former observations recorded in the previous report (6).

Cover crops.—The grass and arable cultural experiment on apple trees continues to give results along the lines previously indicated. Trees receiving grass plus 5 cwts. per acre of nitrate treatment are much less nitrogenous than those under arable treatment only (6).

(c) *Manurial experiments.*

Pot experiments.—A new series of sand cultures with apple trees, variety Bramley's Seedling on Malling No. I rootstock, has been commenced. The object is to attempt to grow large trees under various deficiency treatments in order to study in detail the effects of the various deficiencies on fruit quality.

Laboratory work.—Samples of leaves, bark and wood from terminal shoots and of fruits from apple trees, varieties Worcester Pearmain and Bramley's Seedling, growing on adjoining plots, one manured and the other unmanured, at East Malling Station, have been subjected to chemical analysis in an attempt to discover whether differences associated with rootstocks under the two nutritional conditions of the plots exist.

Significant differences in composition of fruits were found associated with certain rootstocks (6). The results on terminal shoots do not show such clear differences, but nevertheless indicate differential rootstock effects.

The effect of various manurial treatments on the quality and chemical composition of strawberries is under examination. The samples selected for analysis from each treatment are of top grade berries and are collected from definite pickings spaced over the cropping season.

Field experiments.—Manurial experiments on the Research Station plots and on various "extension" plots have been continued.

The Station plots include the following :—

(i) Deficiency treatments and the use of dung on apples, black currants, gooseberries and strawberries.
(ii) A "time of manuring" experiment on apples.
(iii) A comparison of various manurial systems on strawberries.

The outstanding feature of all experiments is the effect of potassium deficiency, which is shown in all cases. No other deficiency effect is observable from inspection of the plots.

The excellent effects of dung on strawberries continue to be marked.

Time of manuring has not produced significant effects on biennial bearing in the case of Allington Pippin.

Experiments in the counties on the effects of nitrogenous manuring in relation to cultural systems continue to demonstrate that an annual spring dressing of nitrate at 5 cwts. per acre is not capable of overcoming nitrogen deficiency in apple trees induced by a grass cultural system.

An experiment using two dessert varieties of apples, black currants and gooseberries has been laid down at Cannington Farm Institute in collaboration with Mr. A. D. Turner, Horticultural Superintendent, Somerset County Council, in which various manurial treatments are being examined in conjunction with cultural and other factors. Potassium deficiency has already proved of significance in the trial.

(*d*) *Soil moisture experiments.*

Soil moisture experiments on apple trees and gooseberry bushes were continued.

In each experiment the " moist " and " dry " trees and bushes were grown at soil moisture levels approximating to soil saturation point and 20 per cent. saturation respectively throughout the season.

Storage tests on the fruits from the " moist " series of apples were carried out, and fruits from both "moist" and " dry" series of the apples are available for storage tests in 1931.

Chemical investigations are in progress on the shoot portions and fruits of the gooseberry bushes to determine whether the treatments produce effects on the intake of nutrient elements.

(*e*) *Leaf scorch.*

Pot and laboratory experiments.

Waterlogging experiments.—Waterlogging did not affect the composition of the ash of gooseberry bushes.

Rootstock and scion effects in leaf scorch on apples.—The apple trees on the various rootstocks are ready for planting in pot cultures.

Chemistry of leaves, stems and fruits in cases of leaf scorch.—The major investigations have been concluded and the results published (7). The data show clearly the relationship between leaf scorch and potassium deficiency in all cases, and how amelioration of leaf scorch by potash manuring is accompanied by increased content of potassium in the various parts of the trees.

The potassium status of leaf scorch soils and the fate of potash applications to such soils.—Comprehensive laboratory investigations relating to these subjects have been commenced.

In the initial stages determinations of water-soluble potassium and replaceable potassium are being made on soils from leaf scorch areas of known manurial history, some of which have been manured in various ways, and other control areas which have been left untreated.

Data both pomological and chemical relating to the trees are available in most cases.

Field investigations.

Investigations on the relation between soil conditions and the occurrence of leaf scorch.—These continue as new cases occur.

Experiments with potash manures and lime in controlling leaf scorch.—At most of the centres the experiments have been in progress for five seasons and, in view of the definite character of the results, the majority will be concluded. Potash manures have given significant results in controlling leaf scorch at all centres.

Lime has not exercised significant effects either on leaf scorch or general growth conditions on gooseberries on a strongly acid soil.

Spraying experiments with sulphate of potash.—Results during the year were vitiated by the extremely wet conditions which prevailed.

(*f*) *The effects of leaching with cold water on the foliage of fruit plants.*

Observations relating to defoliation effects during a very wet summer were continued. Leaves from a centre showing very severe blotching effects have again been collected for analysis.

(*g*) *Nutritional factors affecting fruit quality.*

An exceptionally large programme of storage experiments was carried out to examine, under varying conditions, points previously investigated on a small scale. The results are in general accord with those previously reported.

II. SURVEYS OF FRUIT SOILS (8, 9).

Soil " series " maps of the Pershore-Evesham fruit and market garden areas on the Lower Lias formation have been attempted, and excellent progress has been made.

The main " series " have been determined for the various " clay " areas and these have been mapped.

The " sand " areas remain to be investigated.

Pomological investigations have been well advanced in the Pershore-Evesham area. Special attention was given to the performance of plum varieties on the various soil series. Trees of all varieties are generally superior in growth and cropping on the heavier soils. Rootstock effects are especially important on the lighter areas.

Pomological data relating to apples are complicated owing to "headworking." Failures and poor results due to potassium deficiency, often aggravated by market garden cultural practices, are of common occurrence.

Following on the surveys in the Old Red Sandstone and Lias areas, several manurial and cultural experiments have been carried out which have provided the necessary information required for the solution of various problems which occur. Considerable light has been shed on the action of potassic and nitrogenous manures in particular.

At one centre on the Old Red Sandstone area, after preliminary experiments, a plot has been planted with dessert apple trees to determine whether high grade dessert apples can be produced on the particular soil conditions of the area. Prior to the survey all attempts to grow fruit on the area had failed.

III. INVESTIGATIONS ON SOFT FRUITS.

(*a*) *Strawberries.*

Strain trials.—Work has been continued as indicated in the previous report.

Botanical classification.—Investigations continue as stated in the previous report.

Nutrition experiments.—(See Section I (*c*) of this report, p. 60.)

Abnormal forms of strawberry plants.—The incidence of these pathological types continues to be followed in the Province. During the year special attention has been given to a type of " cauliflower " plant in the variety Paxton and to the form known as " sudden wilt " which has not been common since 1924.

The demonstration on the control of the main forms has been continued on the trial plot in the Cheddar Valley area in conjunction with the Horticultural Superintendent of Somerset County Council.

Anatomical investigations on the roots and crowns of the strawberry plant.—This work is in abeyance.

Insect pests, etc.—(See Sections VII and XV of this report, p. 65 and 66.)

Fungus diseases.—(See Section XV of this report, p. 66.)

" *Red plant* " *and* " *cauliflower.*"—The nature of these troubles is still under investigation.

(*b*) *Raspberries.*

The cropping trials of selected varieties have been continued and the results for the early years of the trial have been published (12). The varieties Improved Beehive, Lloyd George and Baumforth A. have given consistently the highest yields over a four-year period. These varieties are also relatively free from disease. During these trials neither Improved Beehive nor Baumforth A. have suffered from mosaic. Baumforth A. is a berry solely suitable for bulk production for jam making. It is too soft and tart for first class punnet sales. Improved Beehive gives a small, sweet, firm berry and is very early. Herbert, an American variety, is very promising, having given over two tons per acre for a four-year period. Red Cross and Duke of Cornwall have given fairly good yields but have suffered severely from mosaic. They are both varieties of distinct merit for first class punnet sales. Norwich Wonder is one of the earliest varieties and, although not such a heavy cropper as some, is distinctly valuable because of its earliness. Pyne's Royal is undoubtedly a really first class dessert variety. The cane, however, does not attain sufficient length and the crop is light, as compared with most other varieties. It is a variety that responds well to a liberal treatment and should be grown where really first class fruit is in demand. Varieties like Devon, Northumberland Filbasket, Goliath and others have been eliminated from the trials because of disease susceptibility, poor quality or failure to crop.

During 1931 samples of the better varieties were tested for canning and bottling qualities, and chemical analyses were carried out on these varieties to ascertain the main chemical features.

(*c*) *Currants.*

Nutritional experiments on black currants.—(See Section I (*c*) of this report, p. 60.)

Black currant pruning trials.—The varieties Seabrook, Baldwin, French and Boskoop are undergoing an extensive pruning trial. Groups of bushes are hard pruned, i.e., half of the bush is removed each year, whilst other groups are lightly pruned. Records of crop weight, season, and quality of the fruit are taken. The bushes have only given one full crop so that critical data are not yet available.

Diseases of black currant.—A large block of black currants has been established with a proportion of bushes infected with " big bud " and " reversion " in each sub-plot. The plot as a whole is sprayed to control as far as possible all sucking insects, and the spread of disease is noted. Data are not yet complete but so far the incidence of new disease does not appear to be closely related to the known sources of possible infection. The fresh incidence of the two diseases on the plot is very small. (See also Sections V, VI and XIX of this report, pp. 65 and 67.)

Red currant classification.—A variety collection has been established. This material has been used to work out a basis of classification and to provide a key for the identification of varieties. In the course of the soil survey work several new and unknown varieties have been found as rogues in commercial plantations. Cuttings of these have been taken for identification.

Pruning in relation to varietal habit of red currants.—The variety Raby Castle has not been fruiting at Long Ashton for several years. It tends normally to fruit on new wood more than do most other varieties. A small group of bushes was taken and half were pruned normally, i.e., hard cutting back of all lateral growths and a moderately hard tipping of the leaders. The remaining half were only lightly pruned. The preliminary trial indicated that the lightly pruned bushes bore a much heavier crop than the normally pruned bushes. A block of 40 bushes of this variety has been planted in the field in order to continue this line of investigation.

(*d*) *Gooseberries.*

Variety classification.—This work is being continued and several new varieties have been added to the collection. A key for the identification of varieties is being evolved.

Gooseberry diseases.—(See Section XX of this report, p. 67.)

Variety trials.—A variety trial has been established to determine suitability for (i) early green picking, (ii) dessert. Only varieties showing promise for either purpose have been included. The bushes were only planted a year ago and have not yet cropped. Forty bushes of each variety are planted as a unit. Records of crop weight, fruiting season, market value and time taken to pick and prune the bushes are taken.

Nutrition experiments.—(See Section I (*c*) of this report, p. 60.)

IV. Fruit Breeding (13).

Observations on the growth, cropping features, etc., were continued on the various seedlings of tree fruits, bush fruits and strawberries.

Several of the seedling black currants and raspberries, and one blackberry continue to show great promise.

Canning and bottling trials are in progress on the more promising seedling varieties of soft fruits.

A scheme for the distribution of the best selected seedlings has been initiated and at the present time five varieties of apples, four of plums, one pear and one blackberry are available for distribution to subscribers under the scheme.

PESTS AND DISEASES AND THEIR CONTROL.

V. Reversion Disease of Black Currants.

(See Section III (*c*) *Currants* of this report, p. 64.)

VI. "Big Bud" of Black Currants.

(See Section III (*c*) *Currants* of this report, p. 64.)

VII. Harpalus ruficornis and other Species of Carabid Beetles Attacking Strawberries (23).

Observations on incidence and injury to plants have been continued as indicated in the previous report.

VIII. Capsid Bugs (19).

Extensive field trials against *Lygus pabulinus* on black currants and the apple capsid *Plesiocorus rugicollis* were carried out in various fruit areas in continuation of previous work.

In the trials on black currants the following materials were used: tar distillate-heavy paraffin washes, containing various proportions of the ingredients; "white" and "half white" paraffins; and a blast furnace tar oil. Satisfactory control of capsids was obtained by mixtures of equal proportions of tar distillate and heavy paraffin at 10 per cent. strength and by the paraffin oils used alone at 5 per cent. strength. Blast furnace tar oil did not effect satisfactory control.

The trials on apples included a high neutral tar-distillate wash at 10 per cent., and tar distillate-heavy paraffin washes used in equal proportions at 10 per cent. strength, both " white " and " half white " types of paraffin being utilised. Effects of time of application were also examined.

At several centres " high neutral " tar wash failed to give satisfactory commercial control and results from this type of wash were generally inferior to those of the tar distillate-heavy paraffin type. Both types of wash proved complete failures at a centre in Kent. " White " and " half white " paraffins were similar in their effects on capsids.

In view of the importance of the pest *Lygus pabulinus*, critical investigations of its life history have been commenced.

IX. PEAR MIDGE (*Contarinia pyrivora*).

Trials are being conducted using calcium cyanide, nicotine and pyrethrum preparations as control substances.

X. APPLE SAWFLY (*Hoplocampa testudinea*).

In two experiments spraying with nicotine at 7 and 10 days intervals after blossom fall was tested. Results were inconclusive owing to weather conditions and absence of pests.

Nicotine applied at various intervals after blossom fall—1 to 12 days—showed that the most effective control was obtained on Worcester Pearmain with the " 5 to 7 days " applications.

XI. DIE-BACK IN PLUMS.

This disease is most common on the main stems of susceptible varieties such as Giant Prune, and an attempt is thus being made to control the trouble by high working of the susceptible varieties. A batch of Giant Prune, top-worked on Pershore Egg (a resistant variety), has been planted out in a young orchard near Pershore where die-back has previously been exceedingly severe.

XII. DIE-BACK IN APPLES.

Following on observations made during the previous season in relation to the association of *Cytospora sp.* with severe attacks of die-back, inoculations with the fungus on healthy trees have been carried out but no positive results have been obtained.

XIII. DIE-BACK IN BLACK CURRANTS.

Further work on this disease could not be pursued since the trouble was not prevalent during 1931.

XIV. RASPBERRY DISEASES.

(See Section III (*a*), *Raspberries*, of this report, p. 62.)

XV. STRAWBERRY DISEASES (24).

Experiments with a view to determining whether " red plant " disease can be transmitted by insects or other vectors have been in abeyance.

Investigations relating to "leaf spots" have been continued. *Septoria Stagonospora Fragariae* was serious in the Hereford area on the variety Paxton and control measures are being attempted. *Marssonina Fragariae* and *Mycosphaerella Fragariae* are also under investigation.

Attempts to isolate a fungus from plants exhibiting "sudden wilt" have all failed. Experiments on the relation of nitrogenous manuring to the disease are in progress.

XVI. COLLAR ROTS.

Work has been continued as indicated in the previous report.

XVII. FRUIT ROTS OF APPLES AND PEARS (25).

Since the development of "allington spot" has been shown to be associated with attacks of various fungi, e.g., *Gloeosporium album*, the possibility of controlling the trouble by late dustings of sulphur is being explored.

XVIII. PLUM RUST (*Puccinia pruni-spinosae*).

Transmission experiments to alternative hosts have been continued. No positive results have been obtained.

XIX. BLACK CURRANT LEAF SPOT (*Pseudopeziza ribis*).

A field trial of the control of black currant leaf spot by the application of a Bordeaux spray after picking was carried out on a 5-acre commercial plantation, the treatment proving very efficacious. The effects on the subsequent cropping will be judged in 1932.

XX. GOOSEBERRY DISEASES.

Methods for the control of *Botrytis* are being studied on one of the Research Station plots which has previously suffered severely from the fungus.

XXI. BLACKBERRY RUST.

A conspicuous rust on a selected wild blackberry has been examined. The rust attacks stems, leaves and young fruits and is provisionally identified as *Keuhneola albida*. Spraying with lime sulphur 1 in 60 did not provide control and caused scorching of the foliage.

XXII. APPLE SCAB.

Field experiments (32, 33).—In view of the excellent degree of control achieved in previous years in the Station plots, only a single pre-blossom spraying was given in 1931. This proved inadequate for a season so highly favourable to the development of the fungus, and it is evident that even where trees are clean from previous season's sprayings at least two sprays must be given to susceptible varieties to ensure a commercial control.

Good results from the full three-spray programme were again obtained in a commercial plantation previously heavily infested by scab.

Dusting experiments were, impossible during the wet season, thus demonstrating the ineffectiveness of dusts under wet conditions.

Salicylanilide at 1 in 1,000 failed to give a control of scab on Stirling Castle and Lord Suffield.

A preliminary survey of the incidence of scab, spore disposal, etc., has been made on a pear orchard prior to a large scale trial in 1932.

Experiments on spore disposal in orchards during the growing season have been continued. Information obtained in this way is of great value in determining sources of infection and the correct times of applying sprays.

Methods of scab infection.—Detailed studies were made of the infection of twigs by the apple and pear scab fungi. The processes of infection and invasion and of the subsequent reaction of the host plants were investigated.

XXIII. APPLE MILDEW.

Various sulphur dusts have been tried as controls. No commercial control was effected.

XXIV. WINTER WASHES.

Work on winter washes was continued with a view to controlling more completely the group of pests which are assailable at this period of the season, and to testing cheaper products likely to prove efficient.

The materials tested were as follows: tar oil-heavy paraffin mixtures; a variety of mineral oils of various orders of purity; and blast furnace tar.

The results with these washes against *Lygus pabulinus* and *Plesiocoris rugicollis* are given in Section VIII.

None of the paraffins at 5 per cent. strength controlled aphis.

Arrangements have been made for testing the ovicidal value of some of the less volatile aromatic constituents of mineral oils.

Certain emulsifiers prepared by the sulphonation of mineral oils have been tested on vegetation with a view to ascertaining their likelihood of causing damage in spray materials. Certain of them produce more damage when used in conjunction with an oil than when employed alone.

A method has been found of emulsifying practically any liquid even when the most saline water likely to be encountered is used. The process entails the use of a mixture containing glue and the sodium salt of an alkylated sulphonic acid, and since it involves the use of an " emulsion mill " it is only suitable for use in large scale manufacture.

XXV. TOXICITY OF MINERAL OILS TOWARDS VEGETATION.

An attempt has been made to develop a test which will show whether mineral oil emulsions used as summer sprays are likely to damage foliage. Some chemical and physical constants of a series of oils were determined, and the damaging effect on foliage of 3 per cent. emulsions of the oils ascertained.

Toxicity to foliage is closely correlated with the "iodine value" as determined by the Hüble or Wijs methods. No mineral oil of any "iodine value" (Hüble) above 1·0 appears safe at concentrations of 3 per cent.

Attempts are being made to render suitable for summer spraying purposes a cheap oil of somewhat high "iodine value."

XXVI. PYRETHRUM AND DERRIS PRODUCTS (15).

The biological standardisation of these products is receiving attention in view of the variability of the different commercial products available.

Pyrethrum washes failed to control the larvae of *Otiorrhynchus sulcatus* attacking glasshouse plants.

XXVII. LEAD ARSENATE PREPARATIONS.

The difficulties experienced with certain brands of lead arsenate, due to poor spreading properties, have been investigated. Colloidal preparations used with Agral I were found to be highly satisfactory.

XXVIII. THE FUNGICIDAL ACTION OF SULPHUR (34).

In this investigation attention during the year has been chiefly concentrated on those constituents of living plants containing the thiol radicle, such as cystein and related substances. The work of the previous year had led to the conclusion that the production of hydrogen sulphide as a result of contact between the living organism and sulphur was due to the interaction of substances of that type and sulphur.

XXIX. TRIALS WITH NEW FUNGICIDES.

Salicylanilide proved ineffective in controlling scab on apples, varieties Stirling Castle and Lord Suffield, at 1 in 1,000 strength. No injury to the foliage occurred.

A proprietary "colloidal" copper compound gave a fair control against leaf spot of black currants, and merits further trial.

Several "colloidal" sulphur preparations were tested against lime sulphur for control of scab, but none was of outstanding merit.

XXX. SYNTHETIC INSECTICIDES.

An enquiry into the possibility of preparing synthetic compounds of insecticidal value, similar to the toxic principles in pyrethrum products, has been undertaken.

FRUIT PRESERVATION AND PRODUCTS (41).

XXXI. THE CHEMISTRY OF APPLES.

Investigations relating to the effects of nutrition factors on the composition of fruits have been continued and the results recorded in the previous report elaborated (6).

The relation between the position of the fruit on the cluster—terminals and laterals—and chemical composition of the fruits during storage life has been examined in detail. The salient points are as follows :—

The initial values for pH and titratable acidity are similar and the values change at similar rates during storage ; at picking, sucrose in the laterals is approximately 1·5 times as high as in the terminals but the rate of loss is higher in the former and towards the end of the storage life the values for the two sorts of fruits are similar ; the higher sucrose value for the laterals results in a lower ratio $\frac{\text{acid}}{\text{sucrose}}$ for these fruits, which probably explains their characteristically sweeter flavour ; the water extractable matter from the two types of fruits lost water at similar rates when subjected to comparable drying processes, indicating similarity in colloidal materials.

The principal constituents of the wax-like coating of apple peel have been examined and have been identified as under :—

(i) the straight-chain paraffin hydrocarbon, nonacosane $C_{29}H_{60}$;
(ii) sitosterol Glucoside ;
(iii) prunol $C_{30}H_{48}O_3$, a substance first obtained pure by Power and Moore in 1910 from the leaves of *Prunus Serotina* ;
(iv) a compound very nearly related to prunol, probably a lower homologue and
(v) an acid related to prunol.

Prunol is by far the most abundant individual constituent of apple peel and it has been shown that the conclusions of previous workers that it is an acid are incorrect.

An abundant yield of prunol may also be obtained from the leaves of *Prunus laurocerasus* and can readily be obtained in a pure form from this source.

XXXII. THE PHYSIOLOGY OF FRUITS.

Effects of nutrition deficiencies on the development of fruits.—The analytical determinations entailed in these investigations are still in progress.

Effect of position on the cluster on fruit quality.—The behaviour of terminal and lateral fruits during storage life has been followed.

The lateral fruits showed more rapid shrivelling ; they lost weight approximately $\frac{4}{3}$ times as fast as terminals ; changes in ground colour were similar for the two groups.

The effects of cultural treatments on maturity.—Two comparisons of differential treatments were made :—

(*a*) bark ringed and not ringed;
(*b*) grass culture and arable culture.

Data were collected relating to chemical composition of the fruits, starch changes, and firmness over the storage period as shown by a pressure tester.

Several intricate problems were met with in attempting to determine starch changes, which render starch determinations unreliable as guides to maturity. Time of picking appeared to influence maturity relationships between the differential cultural treatments. The firmness data will be examined later in relation to the chemical data.

The development of the apple on the tree.—The chemical work has been continued.

XXXIII. Cider Investigations.

Cider and perry competitions. (35).—These competitions were continued. There were 102 entries spread over six classes. A cider variety, tried for the first time, Tale Sweet, from Honiton, Devon, yielded a cider of exceptionally good quality.

The value of Canadian apples for cider making (36).—Nine varieties of apples (Grade III) from British Columbia were tested for vintage qualities.

The varieties Jonathan, Stayman, and Newtown gave the best results. All the ciders lacked " body," due to the low percentages of tannin in the juices.

Cider storage trials (37).—Four different ciders were tested under various cold store treatments. The results indicated that a period of two months cold storage treatment was sufficient to check the fermentation to the desired extent and to retard the loss of flavour incidental to age. The exact point of time after bottling in late winter or spring at which the treatment was given was of little importance, so long as it was not deferred longer than two or three months.

The resistance of metals to cider.—Further " resistant " metals have been tested, only one of which, a rustless steel, proved practically resistant on prolonged submersion in cider.

Influence of sulphur dioxide on turbidity and deposit in perries (38).—In further experiments the addition of 3 ozs. of potassium metabisulphite per 100 gallons of perry has completely prevented the development of the characteristic turbidity and gelatinous deposit in perries made from many varieties of pears. The treated perries were perfectly clear after a period of 6 months.

The use of the centrifuge in the clarification and fermentation control of ciders (40).—Two centrifuges have been used in experiments and have given similar results.

With juices possessing high rates of fermentation a single centrifuge treatment did not suffice to check fermentation when the gravities were above 1·020, whereas, where the juices showed a medium rate of fermentation, centrifuging stopped the fermentation at a gravity of 1·030 or even above this value.

The flavours of the centrifuged ciders were superior to those of filtered controls.

The vitamin content of ciders.—The effect of fermentation and of other treatments on the vitamin content of apple juice is under investigation. The juices used were of the culinary variety Bramley's Seedling, fruits of high and low nitrogen contents respectively being examined.

The addition of sugar syrup to ciders.—Where sugar is added to ciders, the addition should be made a short time prior to the filtration stage: otherwise "after-fermentation" occurs, accompanied by deposit formation.

Alcohol content of fresh juices in relation to the state of ripeness of the fruit.—Over-ripe apples showed a maximum alcohol content of the juice and sound apples a minimum. The state of ripeness, for this reason, affects slightly the determination of original specific gravity.

Effects of addition of tartaric, citric and malic acid on flavour of ciders.—The total acidities of various ciders were raised by 0·1 per cent. by means of additions of tartaric, citric, and malic acids respectively. The order of the effects of these in intensifying the acid character of flavour was tartaric>citric>malic.

Estimation of volatile acids in cider.—The English official method of estimating volatile acids in cider has been compared with the French method (Duclaux): the former gave slightly higher values. Non-volatile acids (e.g., malic and lactic) were shown to contribute to the "volatile acid" value. The development of volatile acids in maturing ciders is being followed.

Gelatinous deposit in perries.—The chemical nature of the gelatinous deposit in perries is under investigation.

XXXIV. PRESERVATION OF FRUITS.

Tests of bottling and canning qualities were carried out on 6 varieties of strawberries, 20 varieties of raspberries, 4 varieties of blackberries and 2 varieties of plums.

XXXV. WILLOW CULTURE AND THE UTILISATION OF WILLOWS.

Variety trial plots.—The variety trials have been continued. Further selections of the Station seedlings have been made and stocks are being multiplied.

The two Argentine varieties have yielded only poor results and appear of little value under English conditions.

The *triandra* hybrids raised at the Station are of excellent quality but require sorting out into purer lines.

Willow breeding.—Several seedlings have been raised from the cricket-bat willow (*S. alba*, var. *caerulea*) and from other tree willows having affinities to this variety.

The production of "smooth" rods.—Various methods of dealing with lateral shoots on rods have been tested with a view of determining the best commercial practice for dealing with the problem.

It was concluded that the breaking of the laterals during growth was the most suitable method.

Treatment of willow pests.

(a) *Insect* (42, 43).—Colloidal lead arsenate preparations, used with Agral I, proved very efficient in controlling *Phyllodecta vitellina* and *Galerucella lineola* on various varieties of willows.

An attempt is being made to correlate susceptibility of willow varieties to insect attack with the salicin contents of bark and leaf portions.

(b) *Fungus.*—The fungus *Melampsora* has been shown to commence its attacks on young shoots by means of spores borne on the dead willow leaves. An alternative host for the fungus is therefore not essential. Spraying late in the season would thus appear to be unlikely to provide efficient control, and experiments are required to show whether spraying at the time of emergence of the shoots will effect adequate control of the disease.

Peeling for white.—Experiments have been commenced to discover methods of producing "white" rods before the usual peeling season. "White" rods have been produced by boiling the green rods until the bark is sufficiently free to move—usually after 20 to 30 minutes. The colour is inferior to that which results from the orthodox method but the rods are satisfactory for many basket-making purposes.

The culture of S. alba, var. caerulea (cricket-bat willow) (44).—Methods for producing long sets suitable for planting in permanent position were further investigated.

The following recommendations are made from the experimental results.

(a) Well drained, moist, deep, fertile land should be utilised for raising sets.
(b) Sets 12 in. long and of two years' growth should be planted at 18 in. by 24 in.
(c) All first shoots, excepting one, should be rubbed off when 6 in. long.

(d) The selected shoot should be allowed to grow freely. Other shoots developing subsequently are only removed when they tend to grow strongly.

(e) The most favourably placed apical shoot is selected at the commencement of the second year to continue straight extension growth of the main shoot.

Under conditions favourable for growth, long sets suitable for planting in permanent places can be produced in two years.

FACTORS INFLUENCING THE STORAGE QUALITIES OF FRUITS (EMPIRE MARKETING BOARD GRANT).

XXXVI. Pot Culture Experiments.

Deficiency experiments.—A fresh series of apple trees, variety Bramley's Seedling on Malling No. I rootstock, was planted as sand cultures to replace the original Allington deficiency trees. The treatments given are "complete nutrient" and partial deficiencies of nitrogen, potassium, calcium, magnesium and phosphorus respectively.

An attempt is to be made to grow the trees to a fair age before cropping them to obtain fruits for storage experiments.

The gooseberries and black currants, which had yielded the crops required from them, have been discarded according to plan.

Soil moisture experiments.—The experiments in which "moist" and "dry" soil treatments are being applied to apple trees and gooseberry bushes were continued.

Storage experiments were carried out on the fruits of the apple trees of the "moist" series from the 1930 crop. The fruits were stored in the ordinary temperature store to see whether bitter pit would develop under such storage conditions. Approximately 90 per cent. of the stored fruits developed this trouble after about ten weeks' storage.

During 1931 the two series were grown with the soil moisture contents at approximately 100 per cent. and 20 per cent. saturation respectively; crops from both series were obtained and have been placed in the ordinary store for further observation on bitter pit.

The gooseberry bushes under the "moist" and "dry" treatments are being utilised to study the intake of nutrient elements under the two moisture conditions. Analytical work is in progress on terminal shoots and fruits.

XXXVII. Storage Experiments (6).

In order that advantage might be taken of the large apple crop of 1930, financial arrangements were made to carry out a very large programme of storage experiments on that crop and to reduce storage work on the 1931 crop, which was expected to be less favourable for the work. Accordingly, an extremely comprehensive programme was planned and subsequently carried out in full during the period under review.

The subjects of investigation included a large number of the orchard factors likely to affect storage quality in this country, and samples relating to similar factors were obtained under various conditions to minimise effects due to local influences.

The main experiments related to the following factors :—varietal effects ; rootstock influences under various nutritional conditions ; age of tree ; manuring—special reference to problems of use of dung ; " high " and " low " nitrogen and potassium ; cultural systems ; pruning methods ; fruit thinning ; bark ringing ; time of picking ; size of crop ; time of storing after picking ; and size grading of fruits.

The tests were carried out in each case in two stores—an ordinary temperature store and a cold store with temperature regulated at 1 deg. C.

The results are still in course of analysis, but it may be stated that they confirm very closely those previously obtained in smaller scale experiments and summarised in the previous report.

XXXVIII. Chemical Investigations.

The chemical investigations were on the same large scale as the storage experiments and were designed to elucidate the main chemical features of the various samples used in the storage tests.

The full results will not be available until the summer of 1932 at the earliest.

XXXIX. Physiological Investigations.

Effect of nutritional deficiencies on the development of fruits.—The chemical results of this investigation are still incomplete.

Effect of position of the fruit on the cluster on fruit quality.—(See Sections XXXI and XXXII of this report, p. 70.)

The effects of cultural treatments on maturity.—See Section XXXII of this report, p. 71.)

The development of the apple on the tree.—(See Section XXXII of this report, p. 71.)

XL. Effect of Orchard Factors on Vitamin Content of Apples.

This work is carried out in conjunction with Dr. S. S. Zilva, of the Lister Institute. The vitamin C content of apple samples, varieties Bramley's Seedling and King Edward VII, of " high " and " low " nitrogen contents in each case, have been compared.

Nitrogen content has been rendered low by two methods—" grass culture " and " bark ringing."

In all cases " low " nitrogen content, which was accompanied by relatively " high " carbohydrate content was associated with higher vitamin content. It is not possible, however, at the present stage to state definitely that the contents of nitrogen and vitamin C in apples are negatively correlated. (10.)

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13. EAST MALLING RESEARCH STATION.

POMOLOGY.

In Relation to Tree Fruits.

(a) *Rootstock investigations.*

Apples.—Indications of rootstock effect upon the scion have now been recorded on 1,613 trees of Lane's Prince Albert for 14 years; on Bramley's Seedling and Worcester Pearmain for 13 years; on Cox's Orange Pippin and Stirling Castle for 10 years, budded upon the stems of a considerable range of vegetatively raised rootstocks. It is obvious that the picture is as yet incomplete, since none of the trees, even in the "very dwarf" group, appears as yet to be deteriorating. In the intermediate groups there are signs that trees on certain stocks such as Nos. VII and IV are reaching a maturity of cropping which is now reflecting itself in a slowing down of growth. Again, whilst on certain of the "very vigorous" stocks all varieties have up to the present shown little sign of cropping, on others, such as East Malling XVI, Crabs A and C, and Long Ashton OF 5, the large framed trees are showing comparatively early fruiting. That the influence of vegetative rootstocks becomes more marked with the age of the tree seems certain, and this brings to the fore complementary problems of cultural and nutritional conditions which are now being studied.

The effect of the grassing down of some 200 trees of Bramley's Seedling and Worcester Pearmain on various rootstocks has, after only two seasons, been very marked. Whilst the cropping and colour on the whole plot has been enhanced, the different response of the trees on different rootstocks is still quite obvious. Similarly, the response of the same varieties on different rootstocks to conditions of starvation and various manures is being followed up.

It would now seem fairly safe to pass a preliminary judgment upon the suitability of some of the East Malling " very vigorous " layered stocks for orchard purposes. Half-standard trees of Lord Derby, Newton Wonder and Allington Pippin, now some 8 years old, all suggest that No. XVI, and Crabs A and C are of general promise. The former is in addition an easy stock to produce in the nursery. It appears to be synonymous with the German Ketziners Ideal—whence it came to this country in 1914. No. XII is remarkable for producing very vigorous trees, but it has been much slower to show signs of cropping, whilst No. XIII does not seem equally suited to all scion varieties.

A wide range of varieties has now been established on the Jaune de Metz Paradise No. IX, and in every case comparative dwarfingness and early fruiting have resulted. There is not infrequently a tendency for the scion variety when worked on this stock to establish itself on its own roots, and also to blow out at the point of union, even after a number of years, if left unstaked—suggestive facts for those engaged in the study of the theoretical side of stock influence.

A further contribution has been made to the theoretical aspect of these investigations. Sufficient data have now been collected from the three series of trees grafted on to both the stems and piece roots of different vegetatively raised stocks to make it possible to state that stock influence lies at least as much in the root as in the stem of vegetative stocks. A paper presenting the evidence has been prepared.

A paper has been published showing how the use of trees on standardised rootstocks has contributed to the elimination of sources of error in field experiments (4), for it has now been shown that, not only does a single variety grow and crop differently on different rootstocks, but even that it responds differently to the same manurial treatment and has a different potentiality for resistance to disease.

Pears.—Whilst there is now evidence to prove that the different quince rootstocks have marked differential effects upon the scion varieties in the early years, recent observations on growth and foliage suggested that, despite the considerable care exercised in planting the unions above ground, a number of the trees had now become established on their own roots. An examination of the below ground portions confirmed this. It seems certain that this phenomenon is much more general than has been expected, and that it may shed a fresh light on the behaviour of trees on quince roots. A new series of trees budded much higher on the stock stem is in course of preparation.

All varieties worked on quince C have produced much more blossom than on quince A and B (Angers and Common), and in those cases, such as Conference, Fertility and Durondeau, where heavy crops have resulted, these are now becoming reflected in the smaller size of the trees.

The Dr. Jules Guyot bush and half-standard trees on clonal races of " free " (*P. communis*) stock are already exhibiting a range of growth and blossom performance. Although some thousands of layers of the principal selections from single plants have now been produced, the majority do not stand the transplanting as readily as apples or plums. Root cuttings (used on a large scale in the commercial production of Mussel plum stocks) are therefore being tried, whilst further selections are being made and tested.

Plums.—Most of the rootstocks possessing any marked dwarfing effect upon plums (common plum, St. Julien de Toulouse and Brussels) have so far proved of very limited value, since they are incompatible to the majority of varieties, so that further selections from seedling races and testing of the subsequent clones are being made. For general purposes a rootstock of the Pershore type, more ready rooting and with better anchorage, is the ideal being sought. Common Mussel is the nearest approach to an all round stock for plums and peaches, but on some soils it is prone to leaf scorch and of course many consider its suckering habit a nuisance.

The Malling selection, Myrobolan B, continues to show the greatest promise as a very vigorous rootstock for all varieties so far tested. Its ease of propagation from wood cuttings and layers also recommends it. Its behaviour in the field even suggests some degree of resistance to diseases such as silver leaf (*Stereum purpureum*) and bacterial die back (*Pseudomonas mors-prunorum*). This latter trouble has necessitated a search for resistant stems and frameworks upon which such desirable yet highly susceptible varieties as Victoria might be " over-worked."

Peaches.—A progress report (3) mainly on the nursery aspect has been published. Various incompatibilities have been found in the young trees, especially amongst the frequently used Damas and Julien rootstocks. The vigour of the tree can be controlled to some extent. In pot culture under glass the trees on Brompton produced outstandingly the heaviest crops.

The trained trees on various rootstocks should, in the forthcoming year, bear their first full crop. Clonal races of " common " peach have been raised from layers and a Myrobolan (*P. cerasifera*) apparently compatible to peaches has been introduced from the Continent of Europe.

Cherries.—(i) *Acid cherry* (*P. cerasus*) *scions.*—The seven year old plantation of bush Morellos now shows a most striking contrast in vigour and habit of growth and behaviour between adjacent trees worked on vegetatively raised *P. avium*, *P. mahaleb* and *P. austera* rootstocks. A younger plantation is already showing considerable differences between the various selections of Mazzard (*P. avium*). Further selections of Mazzard rootstocks will have a preliminary trial with Morello scions.

The experience gained in carrying out the routine cultural, disease control, and marketing operations on these plots has been embodied in a report (9).

(ii) *Sweet cherry* (*P. avium*) *scions.*—The standard trees planted three years ago, worked on a collection of clonal Mazzard (*P. avium*) stocks, are now giving indications of stock influence on vigour, but from the very nature of the material the results are bound to develop slowly.

Certain recently acquired vegetatively-produced acid cherry stocks, the Stockton Morello from California and the so-called Kentish from Australia—reputedly used for dwarfing sweet cherry varieties—are being described and propagated as rapidly as possible for trial with sweet cherry scions in this country.

Propagation.—Much of the work under this head consists of the careful preparation of material for experimental plots, but interesting data from these carefully recorded experimental nurseries become available with reference to peculiarities in the early stages of the life of the plant.

The search for new rootstocks continues and these are being tested for ease of propagation and incompatibility in the nursery.

The experiments in the propagation of fruit tree rootstocks by means of hardwood cuttings and root cuttings are being continued, and findings, which may be of practical value, will be further tested on a commercial scale in the field.

Work has begun on the benefits or otherwise of " stem builders " and disease resistant frameworks for apple and plum trees.

(*b*) *Root development investigations.*

The excavation of the roots of a comprehensive series of mature trees on clonal and seedling roots under very varied conditions of soil, moisture and aeration conditions has given some valuable information as to the parts played by these interrelated factors upon root development. Arrangements have been made with the Dominion of Canada Experimental Farms for following up these preliminary deductions under conditions of artificial irrigation at Summerland, B.C.

The intensive methods of observation of actual root growth upon the two contrasting types of root-system (Nos. I and II) were elaborated this season. Eight young trees are being grown in observation boxes with glass sides, filled with different soils, and suspended below ground level in darkness. Frequent observations of growth were measured and recorded photographically and some valuable micro-photographic details obtained.

A 13 year old root-system of Lane's Prince Albert on No. I rootstock was kept under constant observation by means of an observation trench with glass windows—the whole being kept darkened. It is intended to extend these observations to other rootstocks in the forthcoming season.

The importance of soil temperature and moisture in such observations is obvious, and preliminary efforts have been made to record and control these. This has involved some work upon possible soil moisture recording apparatus, and it is hoped ultimately to regulate these factors in the observation cases.

(c) *Investigations in biennial bearing.*

These have been commenced with apple trees, and, in an attempt to analyse the causes, the removal of part or all of the fruit buds, at different stages of development, from either the whole or parts of the trees already exhibiting the habit, is being carried out. Records from the rootstock, pruning, fruit thinning and manurial field trials are also being analysed from this point of view.

(d) *Double working of fruit trees.*

Sufficient data have been collected over the past twelve years to show that certain combinations of "intermediate" and second scion give good or poor results as affecting the initial union and subsequent growth and fruiting. It is at least possible to warn growers and nurserymen that it is dangerous to top work any one variety upon any other without previous experience, and that supposed suitabilities from *a priori* reasoning have proved failures —as in the case of the use of Bramley's Seedling as an invigorating intermediate for Cox's Orange Pippin. Again, certain generally suitable intermediates for double working pears on quince have also been indicated. At present however no general principle for right selection seems emerging from field trial methods, and it will only be by an exhaustive series of combinations of intermediate and second scion that the desired information can thus be acquired.

(e) *Investigations into the non-setting of the blossom of certain varieties of pears.*

The influence of rootstock and pruning methods upon the blossoming of pears has for some time been under investigation. These studies have emphasised the fact that, whilst certain varieties may be made to produce blossom in the early years by these methods, fruit setting does not necessarily follow. A concerted attack on this problem from the point of view of cross pollination, stem-ringing, fruit bud thinning, nutrition, doubleworking, etc., is being made.

(*f*) *Pruning.*

Apples.—For the study of pruning along the original lines, the pruning plot has now reached the end of its usefulness, and a review of its 17 years' performance is nearing completion. The present state of some of the trees raises entirely new problems—their present pruning needs calling for a radical change of scheme. Investigations of renovation by dehorning, thinning, spur thinning and shortening have already been started. On a number of young trees the question of the optimum time for leader pruning will be studied.

Pears.—These investigations are being maintained and developed in the light of the addition to the programme, Section (e).

Plums.—The pruning and thinning of plum trees at different seasons of the year is closely bound up with the problems of bacterial die back and silver leaf infections, from which point of view they are being developed.

Cherries.—A trial of the best methods of pruning developed bush Morellos has been commenced.

(*g*) *Fruit thinning.*

Plums.—Two reports have been issued on the very definite results of a single year's experiment on the thinning of Victoria plums (5, 7). The increase in size and quality of the fruit and the higher net return compensated for the actual lower aggregate yield of the thinned trees. The thinned trees had practically no broken branches, whilst the unthinned were severely damaged. The labour costs too were found to be favourable to thinning. These experiments will be continued when sufficiently heavy crops are available, and extended to certain other varieties of plum.

Apples.—The experiment started in 1927 on young trees has been continued and extended. Certain effects on tree growth etc. are already obvious and it is hoped to issue a progress report shortly. The results of thinning the fruit on 13 year old trees of several varieties have so far been less decisive.

(*h*) *Manuring of fruit trees.*

Apples.—The discovery that the same variety of apple on different rootstocks shows a significantly different response to the withholding and application of fertilizers has led to the development and further layout on older trees of known history of specially designed field experiments, in which the interaction of variety, rootstock, manures, cultural conditions, etc., will be closely observed in relation to fruit crop, quality, disease susceptibility, biennial bearing, etc., over a period of years. It is already evident that, under modern methods of standardisation of material, plot lay out, and recognition of deficiency symptoms, indications of a differential response can be detected in quite young trees.

Stone fruits.—In view of the seriousness of the bacterial die back of stone fruits, the nutritional aspect in relation to possible inducement of susceptibility is to be investigated in collaboration with the pathology section. A start has been made with Victoria plums in pot culture and young stocks in the nursery, prior to an extended study in the field.

(*i*) *Variety collections and trials.*

The observations made on the apple and pear collections over a number of years have been reviewed during the year. Most of those varieties which are worthy of retention for further trial, breeding purposes, or on account of particular peculiarities, are being worked on very dwarfing apple (IX) and quince (C) roots and transferred to the cordon " library."

Considerable work has been done on the nomenclature of the very extensive collection of cherry varieties.

(*j*) *Fruit breeding.*

Rootstocks.—The raising of new apple rootstocks combining immunity to attack by woolly aphis with the desirable characteristics of certain of the Malling series, undertaken in collaboration with the John Innes Horticultural Institution, is progressing. Certain of these new seedlings of proved immunity have now been propagated in sufficient quantities to allow of their being worked with Lane's Prince Albert for an intensive nursery trial of their performance. Since approximately not more than 5 per cent. of these crosses produce immune seedlings, a joint effort is being made to raise up to 1,000 per annum for testing.

Over nine hundred seedlings from crosses between the Malling selected rootstocks are being " stooled " this winter to test their potentialities for vegetative propagation. It is hoped from amongst these to find some improved rootstocks, combining the best qualities of some of the existing ones.

Scion varieties and the shortening of the " juvenile " period.—Further seedlings from crosses between apple varieties were raised during the past season with the object of obtaining a succession of new varieties of good quality and colour.

A large batch of seedlings has been worked on dwarfing and vigorous rootstocks to test further the effect of the rootstock in shortening the " juvenile " period of such seedlings. A preliminary experiment suggested that this possibility was worth further investigation. At the same time an adult tree is being top worked with young seedlings. Meanwhile material is being prepared for a larger and more definite trial.

The work of raising pear seedlings designed to produce new varieties of high quality and extended season is being continued.

(*k*) *Pomological aspects of spraying.*

This work is being developed by the pathology section (see p. 97) in relation to the new field experiments detailed under (h).

(*l*) *Marketing problems.*

The influence of such factors as variety, stock, pruning, thinning, cultural and manurial conditions is being carefully watched in relation to market value over a series of years. (See (g)).

(*m*) *The Kent fruit soils survey.*

The pomological survey of the Lower Greensand has been concluded. Detailed records have been taken in 924 plantations on 147 farms, the total area surveyed being 4,225 acres. This comprises about one quarter of the total acreage of fruit in the area and is representative of the whole. Analysis of these records has given very useful information with regard to the distribution of kinds and varieties.

The farms surveyed in the third year were mainly on the Folkestone Sand east of Bearsted and on the Hythe Beds in the Otham-Langley-Loose district and east of Egerton.

Further correlative work has shown that on a number of the soil series a definite standard of growth of fruit trees and bushes can be expected. This may vary with kind and variety of fruit and be the same for a number of the soil series. The great importance of soil water conditions has become clear.

The necessity for consideration of a large number of factors before a certain standard of growth is attributed to soil conditions has been confirmed.

(*n*) *Walnuts.*

Propagation.—Vegetative races of representative varieties of *J. Nigra*, *regia* and *Californica*, etc., are being raised by layering and soft wood cuttings as a basis of rootstock investigations. Stools were opened up in November, 1930, and the layers were counted on each stool. Rooting on the layers and on old wood was noted, and the percentage of rooting on the layers was recorded. The layers were then cut off and planted.

Methods of grafting under glass and of grafting and patch budding in the open nursery are being tried on seedling *J. nigra* stocks from a known parent. 130 trees were raised under glass last year, bringing the total number of grafted trees raised since the work was commenced to 698. Only about 12 per cent. of the trees worked in the open nursery have so far been successful, but even this small percentage is sufficient to indicate the possibilities of outdoor propagation if the correct technique were found. Experiments will be continued in this direction.

Varieties.—Altogether 64 American, Continental, Eastern and English varieties of walnut have been obtained. It is proposed to grow these at two centres at least.

Twelve varieties have been definitely selected for rapid propagation and distribution and six sets of twelve trees each, including most of these selected varieties, are being distributed to different localities.

Last spring records were taken of dates of leafing out of trees in nursery beds in order to find out which varieties are likely to be injured by frost in this climate.

The larger trees planted in the open and in the Orchard House were hand pollinated last year. The resulting nuts (from the Orchard House) were collected and records of dimensions, quality, sealing, etc., were taken. Enquiries for grafted walnut trees have been received from Australia and South Africa.

Observations on established seedling trees.—In the winter, 1930, graftwood was collected from the five competition trees which are being propagated, and from the tree at Leeds Castle which bears nuts in clusters.

In the spring, 1931, information was obtained in writing on the question of pollination of the above trees. In every case it is now known whether the trees were self or cross-pollinated in 1931.

In July, 1931, the crops from the tree at Leeds Castle and from another tree in Kent were obtained. These trees bear small soft-shelled nuts in large clusters. Samples from both trees were tested by two pickling firms with very satisfactory results.

The competition trees were visited in August, 1931, and notes were taken on the probable crop, the disease present, the condition of the tree, etc.

Oil content determination work.—The percentages of oil and moisture were determined in January, 1931, in samples of fresh nuts from the six mature seedling trees selected at the walnut competition in 1929. These results were compared with those obtained by Mr. Spence in 1929. It was found that the oil content of these nuts, though still higher than the average, was slightly lower in every case than in 1929. This was to have been expected on account of the heavy rainfall in 1930, when the nuts were maturing.

Curing and storage trials.—Two samples of nuts were used (i) from one of the selected competition trees, therefore of known high oil content, and (ii) an average sample from a local tree.

After deshucking and washing, a portion of nuts from each sample was dried in the furnace room at 90° until no more moisture was lost. The fresh and dried nuts were then submitted to various fungicidal and bleaching treatments and stored in earthenware pots in salt, peat moss fibre, coconut fibre or sulphur at a temperature of 36° F. Five nuts were removed from each pot every month from November to April, inclusive, and examined for plumpness of kernel, appearance, disease, etc.

The best results were obtained from nuts which had been bleached in chloride of lime and then stored in coconut fibre or salt. Salt is unsatisfactory in that it is extremely deliquescent. Experiments are being continued to see if better results are obtained by dipping the nuts in a saturated salt solution before storing, so that the salt is present as a thin deposit on each nut instead of in a surrounding mass.

The kernels of high oil content remained considerably more plump than the "average" kernels. At the end of the season dried nuts were richer and less plump than fresh nuts, but did not appear to be less prone to attack by fungi, as was expected in view of their lower moisture content.

Diseases.—(See under Mycology, p. 93.)

IN RELATION TO THE SMALL FRUITS.

(*a*) *Nomenclature, classification and variety trials.*

Now that a centralised variety testing scheme is supported by the Ministry of Agriculture, and that in the case of currants and raspberries East Malling has established a satisfactory technique for crop comparison, this work will not be developed, except as a sub-station of the central testing station.

The cropping trial of the Malling clonal races of red currant, established three years ago, will be allowed to run its normal life, and sufficient figures should have been collected on the black currant plots, designed for triplication at Long Ashton and Wisley, to permit of their summarisation.

Papers describing the methods of identifying the chief worthless rogue varieties, commonly found amongst and sold as Baldwins' black currant, have been published (13, 16).

Two papers summarising the results of the raspberry cropping trials have been issued (11, 12). In future only a few specimen plants of some 60 of the more important varieties will be saved for reference purposes.

About a dozen of the more important varieties of blackberries and dewberries are being described and given a preliminary trial.

(*b*) *Propagation and the establishment of clonal races.*

The logical outcome of the classification work has been the establishment of healthy clonal races of small fruits from selected type parent plants. In the case of red and black currants and a number of raspberry varieties, these reselected clones are now available for distribution in considerable quantity, and they are believed to be disease free. The amount of "reversion" in the clonal black currant plantations is negligible, and if all exterior sources of infection could be removed would probably disappear altogether. Similarly mosaic-free races of certain raspberries are well on the way to establishment. Pure races of those varieties of gooseberry required for cultural and manurial trials are now available.

Clonal races of Royal Sovereign strawberry are being multiplied, and each individual runner with its progeny kept under observation in certain cases. Any possible "degeneration" from methods of runner selection, as distinct from the intervention of disease, is being watched, whilst suitable material for an extension of cultural experiments is being built up. The best methods of raising and transplanting some of the more important varieties of *Rubi* are being sought on clonal material.

(*c*) *Planting, training, pruning, etc.*

The strawberry "uniformity" trial, planned for a study of the variability of plants in the field, is yielding valuable information which will be utilized in the future layout of strawberry investigations. Papers have been published (14, 15) dealing with the effect of strain, time of planting and de-blossoming upon cropping, size of plant, and runner production, in a three year experiment, designed upon statistical principles. Selection of healthy parent plants has considerably reduced the variation between the strains. Under East Malling conditions, early autumn planting has given the best results in cropping, vigour and runner production. De-blossoming increased both size of plant and runner production. These questions are receiving further attention..

Various methods of pruning red currants and gooseberries in conjunction with certain cultural and manurial treatments are under elaboration.

The training of loganberries is being studied in relation to cropping as well as disease factors.

(*d*) *Manuring.*

The raspberry trials, planned on modern methods of layout, have, after four years of differential treatment, come under review, and a report demonstrating the value of the methods used and detailing certain interesting manurial results has been prepared for publication (see also under Statistics, p. 88).

(*e*) *Fruit breeding.*

Black and red currants.—Approximately one thousand seedlings, the result of crosses between the main varieties of black currants, are being examined in detail, in an attempt to elucidate the inheritance of numerous characters. Certain seedlings from a further plot of a thousand bushes, now four years old, have given promising indications of heavy cropping. After another season, the most outstanding will be selected for further trial. Two of the original seedling crosses, Wellington's Triple and Double X, have now stood some 12 seasons' test. They combine certain very desirable qualities and several growers who have tried them on a commercial scale are anxious to obtain further supplies.

Through the kindness of the Director of the John Innes Horticultural Institution, it has been possible to arrange for a preliminary experiment on the artificial production of mutations in black currants by subjecting seeds, flowers and pollen to X radiation. The treatments are to be carried out at Merton and the resultant seedlings raised at East Malling. It is possible that such mutations may in certain cases prove of economic value.

Crosses between Black Currant varieties and nearly related *Ribes* species are being raised in the hope that such hybrids will contain new and desirable combinations of characters. The Station's collection of such species is being augmented as opportunity offers. A number of seedlings from crosses and selfs between red currant varieties are now under observation.

Raspberries.—After a first selection, some 40 seedlings promising to show some improvement upon the commercial variety Lloyd George have been reserved and propagated for further trial. It is intended during the next two years to reduce this number to three or four and then to offer these for final trial under the Ministry's central testing scheme.

Further selfs and crosses are being made.

STATISTICS AND RECORDS.

The summarisation and analysis over the past three years of the considerable mass of accumulated data (over the past 13 years) have borne fruit during the past year, whilst the trial of methods of plot layout, comparatively new to horticulture, is now sufficiently advanced to make it possible to lay down certain general recommendations for the conduct of field experiments with fruit plants.

Plot layout.—The older methods of plot layout, where an indefinite number of trees were scattered about the ground with little regard to the subsequent interpretation of their performance, have been superseded by modern methods of layout, such as those now common in agriculture (e.g., the method of randomized blocks), adapted to the peculiar difficulties met with in permanent crops.

Enough is now known of the variation in such diverse crops as strawberries, raspberries, currants, apples and hops to enable trials to be laid down with an adequate, and at the same time economical, number of repetitions to prove the kind of differences which are to be expected.

It has been possible to review several of these new trials during the year, especially those with small fruits. These trials have shown very clearly the value of the new methods, not only in their accuracy, but in the more complete information as to the interaction of two or more treatments or the differential responses of different varieties to given treatments.

A report on the layout and interpretation of two manurial trials of raspberries is in preparation.

Technique of recording.—The recording of the tree's life history has been made a subject for special study. The various methods of measuring the growth and cropping in trees have been reviewed, and it is now possible to make recommendations as to the necessary measurements to be taken. For example, the relationship between the girth increments, annual shoot growth, and other measurements of tree vigour has been examined with a view to discovering which, if any, of these can best determine the vigour at any particular time. The fact that none of these alone can adequately express this has brought a new train of problems, such as that of measuring annual shoot growth on older trees, where the enormous growth renders the measurement of any great number of trees a physical impossibility.

In this connection a method of sampling the growth of spur pruned trees has been developed, which depends to a large extent on the weight of those prunings, and is now in use on several plots.

Other methods of sampling have been worked out, such as that in use for measuring the ratio of blossom production to fruit set.

These findings have been set forth in several reports published during the year. A paper published in the proceedings of the Imperial Horticultural Conference was further expanded into a memorandum (6) dealing in great detail with the matters discussed above, including a section on experiments with tropical fruits, and giving several examples and the methods of working out the results in detail. It included a bibliography of over one hundred papers on the subject.

In the summer two short papers dealing with technical methods and the peculiar difficulties of extension trials were prepared and read at conferences. The former has already been published (10).

PHYSIOLOGY.

Vegetative propagation.

Investigations on the conditions favouring rooting in hardwood cuttings have been continued in collaboration with the Propagation Section. Improved rooting in plum cuttings has again been secured by placing a layer of sphagnum moss beneath the sand of the cutting bed. A layer of spent hops was not so effective as the layer of sphagnum. No marked improvement in rooting was obtained by shading the cutting bed with muslin in late spring and early summer, but the combined effect of shading and of a layer of spent hops is being tried this season. The investigation of the effect of the time of planting upon rooting is being extended to include the planting of cuttings early in September. A number of cuttings was made last autumn from shoots whose bark had been previously ringed, notched or split at the point where the basal cut was subsequently made ; these cuttings, however, are being left in position for another year. The effect of treating the base of the cuttings, before planting, with dormancy-breaking chemicals, such as ethylene, chlorohydrin and thio-urea, has been tried ; these cuttings, too, are being left in the cutting bed for another season.

Leaf relations in apple trees.

Investigations to determine to what extent the influence of rootstock, pruning and cultural treatment upon vigour, precocity and other characteristics of a tree becomes effective through their influence upon leaf relations have been continued. Since practically the whole of the supply of the very important element carbon, which makes up the greater part of the dry matter in a tree, is obtained through the agency of the leaves, any factor that alters the amount of leaf surface, the time of year at which it is developed, or the efficiency of the individual leaves, may be expected to influence the behaviour of the tree, by altering its carbon relations.

Before a thorough investigation of this problem could be attempted, a quick and accurate method for determining the area of the leaves without detaching them from the tree had to be elaborated. This has now been done and the method has been applied this autumn to the measurement of every leaf on two nine year old Laxton Superb apple trees, one on Malling No. IX, the other on Malling No. V. There were about 10,000 leaves on the one and some 20,000 leaves on the other. The main objects of this investigation were to test the technique on large trees, to get some indication of the magnitude of the differences in leaf relations to be expected as a result of stock influence, and to explore the possibility of applying some form of the " sampling " method to the estimation of the leaf relations of a tree. The preliminary work is now sufficiently advanced to enable the fuller investigation to be begun next year.

Growth.

Seasonal course of root and shoot development in apple stocks.—The investigation into the seasonal course of growth in an apple stock and into its distribution between the various organs—roots, stems and leaves—has been continued and a progress report (17) has been published on the growth during the maiden year of trees planted in the springs of 1929 and 1930. The trees were weighed before planting and were lifted in random samples of about 50 at intervals of about a month. Their rates of growth at different seasons were determined from the differences between the weights of successive samples. The increase in weight of a tree during its maiden year was found to be more or less proportional to its weight at planting. Thus trees that were six times as heavy as others at the time of planting were still six times as heavy at the end of the growing season ; in each case the weight (including leaves) at the end of the season was about double that at the time of planting. This emphasises the desirability for using first grade material for "working" ; low grade material will not even up with high grade by a faster rate of growth during its maiden year. The curve of increase in leaf weight was of the usual S form in both years and that for increase in root weight during the growing season was of the same form in 1930. In 1929 there was a depression in the rate of root growth in August which corresponded with a spell of very dry weather. The whole tree decreased in weight during the winter months ; this was especially marked in the case of the roots in the winter of 1929–30, due perhaps to excessive dying off of young roots owing to the very wet conditions incident that winter. The course of growth during the second year after planting has been investigated during the current year and will be followed until April, 1932.

Effect of scion on root.—Material has been prepared for seasonal observations on leaf, stem and root development in the two apple varieties Grenadier and Beauty of Bath, in order to investigate the causes for the marked difference in the amount of root produced by stocks worked respectively with the two varieties.

BIOCHEMISTRY.

Stock influence.

The general lines of attack have been outlined in two progress reports (19,20). Work last year on this problem was confined almost entirely to evolving methods to solve the very difficult analytical problems which have arisen.

Ash analysis.—Work on Heyrovsky's polargraphic method for estimating minute amounts of metallic elements consisted of a few attempts to replace the dropping mercury cathode which had been found troublesome. Recently published work of Heyrovsky's co-workers having demonstrated the necessity for greater complication of the polargraphic method than at first seemed necessary, the spectrographic method then appeared the more promising one to develop first.

Spectrographic apparatus purchased with a grant from the Government Grant Committee of the Royal Society has been set up. The large number (over twenty) of elements present in the ash and the limited amount of ash available necessitate a highly efficient sparking apparatus. A number of pieces of such apparatus have been built up and tested. The one now being tested appears likely to be satisfactory.

Functions of the ash constituents.—Observation of the trees injected last year (20) has revealed the quantities of the various substances which may be injected with safety. There was a suggestion that an injection of sodium thiosulphate in the autumn suppressed the primary mildew infection in the following summer but had no effect on scab. Material was prepared for determining the function served by molybdenum in Type IX rootstock.

Resistance of different rootstocks to insect attack.

(Jointly with Entomological Section.)

Causes of resistance to woolly aphis.—In the first progress report (21), in which the methods of attack were outlined, two artificial culture methods were described. The one in which the woolly aphides have to puncture a membrane to reach the food has been improved and has given better results than the agar method.

The average length of life of the adult insects was not appreciably affected by taking them from their natural host and placing them on artificial media, but the average length of life of the young born after the mothers were placed on the artificial media was short, nine days being the best so far obtained. The figures suggest that in the preparation of most of the media, both from susceptible and immune bark, some substance toxic to the nymphs had been produced or liberated. The properties of this substance correspond with those of anthocyanins which have been recognised in apple bark (see following section). In seven out of eight comparisons between media, differing only in the one being prepared from immune, and the other from susceptible bark, the susceptible bark medium gave the longer nymphal life. In the one comparison made between three media made from immune bark, susceptible bark and a mixture of the two, the nymphal life period for the last was about equal to that from the susceptible bark. These results suggest that the difference between immune and susceptible trees was extracted unchanged by the methods employed in making up the media, and that the differentiating substance is a food, necessary to the insect, which is lacking in the immune. This statement rests on too few facts to be looked on as more than a basis for further work. In so far as it is confirmed it will be a justification for a detailed search for the food substance by combined chemical and biological methods.

Chemical examination of apple bark.

This work arose out of the need, for the woolly aphis immunity investigation, of determining the best method of extracting the constituents of apple bark (i.e., all tissues outside the cambium) in as near as possible the condition in which they exist in the living tissues, it having been found that at least one compound, occurring in the living bark as a bright red solution, was changed in the extraction into a brown insoluble substance.

A machine consisting of a shielded tempered steel wire wheel rotating at 2,800 R.P.M. has been devised to reduce bark to a fine state of division and shoot it into a solvent in one operation.

From the bark of Allington Pippin shoots with this machine, using alcohol as solvent, a solution was obtained from which fractional precipitation with lead salts isolated a red and a yellow substance with green and yellow lead salts respectively. The substances appear to be anthocyanins.

The distinctive red and yellow colours of the shoot barks of certain apple rootstocks are due to the presence of these substances and the colour of the lead precipitate has been found to be a fairly constant characteristic of apple, rose and cherry stocks. Similar precipitates from apple and rose roots varied according to the variety from lemon yellow to reddish brown. Chemical methods of identification based on the above facts have been worked on.

Some evidence has been obtained that varieties of rootstock differ in respect of a number of crystalline constituents which have not yet been identified, but an examination of which may well be of interest in connection with varietal differences of susceptibility to disease, etc., as well as in the study of varietal differences in general and of the rootstock effect. This work will proceed as opportunities occur.

PLANT PATHOLOGY.

MYCOLOGY AND BACTERIOLOGY.

Crown gall.—The relative susceptibility of apple stocks to crown gall.

A progress report detailing the preliminary experiment carried out in 1929 to determine by artificial inoculation under uniform and controlled conditions the relative susceptibility of apple stocks to crown gall was published in 1931 (30). In this experiment stock No. VII was markedly more susceptible than No. I, both with regard to the relative numbers of successful inoculations and to the size of the resultant galls. On the basis of these results an extended series of experiments was carried out in 1930 and 1931, including a larger range of Malling stocks, and consisting of (i) a pot inoculation test on similar lines to the 1929 experiment and (ii) parallel field experiments in which the same series of stocks was subjected to the conditions of natural soil infection. The results of these experiments, which confirm those of the initial experiment in 1929 with regard to stocks Nos. I and VII and have provided information on the relative susceptibility of the other stocks included in the tests, are being prepared for publication.

Brown rot diseases.

Three diseases caused by the brown rot fungi have been under investigation.

(a) The common fruit rotting fungus *Sclerotinia fructigena* has been found to produce brown rot cankers on a number of varieties of apples. The fungus first infects the fruit and then extends from the fruit into the spurs and branches to cause cankers. It is important that such cankers should be noted and carefully cut out, for if they are left the fungus spends the winter in them and reappears at the surface the following year to cause further infection (23).

(b) Observations on blossom wilt of Morello cherries made in May, 1931, showed that in that year there were two waves of infection, one occurring before the flowers opened and the other during the blossoming period. In both cases the twigs were invaded from the infected flowers and killed back several inches. It is recommended therefore that all dead twigs should be cut out as soon as wilting is obvious, to eliminate sources of infection, and that the bushes should be sprayed with Bordeaux mixture soon after the buds burst in order to protect the unopened flowers (34).

(c) A blossom wilt of Fertility pear trees has been found to be caused by *Sclerotinia cinerea* forma *pruni*, the fungus which also causes blossom wilt and fruit rot in plums and cherries (22).

Bacterial diseases of fruit trees.

It has been found that certain diseases, which result in great losses in plantations of plums and cherries in this country, are caused by bacteria. Organisms associated with these diseases have been isolated and are being compared in reference to their cultural characters and infective properties.

A wilting of young green shoots on Victoria plum trees has been found to be caused by a bacterium which has been isolated from naturally infected shoots, and when inoculated into healthy shoots has reproduced the disease. Cultural tests indicate that the organism is one that has not previously been described and it has been given the name *Pseudomonas prunicola* (24).

A more serious disease of plum trees is bacterial canker, a form of "dieback." Isolation and inoculation experiments have shown that this is caused by another organism, which, however, is closely related to *Ps. prunicola*. The symptoms accompanying bacterial canker have been recorded and the results written up and submitted for publication. The behaviour of the causal organism in pure culture and its mode of infection are being studied. The relation between the stem cankers and the infection of the foliage (bacterial leaf spot) is being investigated with a view to discovering at what period of the year control measures are most likely to be effective. It has been found that the organism spends the summer on the leaves (leaf spot stage), and the winter in the stems and branches (canker stage). Control measures therefore are being directed towards controlling the leaf spot stage during the growing period, and protecting the stems against infection in the autumn.

Observations made on the relative susceptibility of varieties of plums to bacterial cankers have shown that certain varieties rarely become infected, and such varieties may therefore serve to provide stems or "frameworks" on which to "over-work" the more susceptible but more valuable varieties. Trees are being raised for trials along these lines.

Raspberry diseases.

Cane spot (*Plectodiscella veneta*).—A paper describing work on this disease carried out from 1924 till the close of the 1929 season was written and published in 1931 (33). In this paper the symptoms of the disease as they occur in Great Britain are described, and data relative to varietal susceptibility collected over the period are summarised. The isolation and identification of the pathogenic fungus and inoculation experiments to establish its pathogenicity are briefly described and salient points in its seasonal cycle are given. Experiments are described which show that the disease on highly susceptible varieties may be controlled (i) by a modification of cultural methods and (ii) by spraying with Bordeaux mixture or with lime sulphur. With the limited schedules used the former spray gave the most reliable results. Finally the severity of the attack of the disease is shown to vary greatly from season to season. The causes of this variation are discussed and a routine schedule of control measures is suggested.

Cane blight (*Leptosphaeria Coniothyrium*).—Observations on the symptoms of this disease and the seasonal cycle of the causal fungus have been continued. In addition to the varieties Bath's Perfection and Reader's Perfection mentioned in the 1930 report, serious attacks at East Malling on the varieties Pyne's Royal and Goliath were noted in 1931. Preliminary spraying trials carried out in 1930 gave negative results. There was evidence, however, that control can be obtained by cultural methods, and a further experiment to test this was commenced on a grower's plantation in the 1931 season.

Raspberry mosaic.—The results of the past twelve years' research on this disease indicate that its incidence has a very serious bearing on the future of raspberry cultivation in this country and suggest at the same time the lines upon which its control may be achieved.

This research has been conducted from the two following points of view :

(a) A study and analysis of the leaf symptoms of the disease, and of the correlated effect of infection on the subsequent history of the plant, have been made with special reference to the very striking differences in varietal susceptibility noted. This aspect of the work has been carried out (i) by systematic field surveys and observation carried out during the whole period, and (ii) by a series of controlled transmission experiments using grafting methods.

(b) The rapidity and mode of spread of the disease on susceptible commercial varieties under normal field conditions has been studied and attempts made to check this spread by roguing methods.

On the basis of the results obtained along the above lines of work, a scheme for the control of the disease by raising mosaic-free cane of susceptible varieties on specially designed propagating plots was formulated, and experiments to test it started in 1928. The first two years' results of these experiments were sufficiently satisfactory to justify the laying down of similar plots in 1930 on farms of certain growers and Farm Institutes in Kent and Sussex in order to test the scheme under varying conditions. Detailed reports embodying the results of the work outlined above are in course of preparation for publication.

Loganberry cane spot (*Plectodiscella veneta*).

A preliminary spraying trial for the control of this serious disease of loganberries was carried out in 1931 at the Research Station. The treatments consisted of single applications of lime-sulphur at two strengths at the " delayed dormant " stage.

Although the complete results of this trial will not be available till 1932 it is clear by inspection that the control afforded by this treatment is not adequate. Observations made during 1931 strongly suggest that the serious attacks of the disease are due in part to the method of training now in common vogue. On the basis of these observations an experiment has been planned to determine the degree of control obtainable by combining a simple spraying schedule with various training methods.

Diseases of cultivated blackberries.

" Blue blotch " disease (*Septocyta ramealis*).—A serious attack of this disease on a commercial plantation of blackberries was investigated. Preliminary experiments show that a degree of control can be obtained by modified training methods.

" Reversion."—A preliminary investigation was made of an increasingly prevalent disease of the Himalaya Giant and the cut-leaved varieties of blackberry which causes the canes and flowers to develop abnormally and results in complete sterility and ultimately in the death of the infected stool. The symptoms strongly suggest that the disease may be caused by a virus, and material was collected during 1931 with the object of carrying out transmission experiments. The possible relation of a species of mite constantly associated with " reverted " plants to the disease is being investigated by the Entomology Section (see also p. 102).

Strawberry " Yellows."

The study of a serious deterioration disease of strawberries, showing symptoms similar to those described by Plakidas in America, was commenced in 1931.

In order to investigate the possible virus nature of this disease independently of the artificial infestation of plants with suspected insect vector, experiments were carried out to determine, in the first instance, the possibility of grafting one plant to another. An account of these experiments, which gave positive results, is being prepared for publication.

It is proposed to continue these experiments in 1932 from the point of view of virus transmission, adopting throughout the method of grafting found to be the most satisfactory in the previous year's experiments.

The possible relation of the strawberry tarsonemid mite, constantly associated with diseased plants, to the disease is also under investigation in collaboration with the Entomology Section (see also p. 101).

Hop wilt (*Verticillium albo-atrum*).

A further series of detailed records on the incidence and seasonal variation of this disease on the affected gardens at Penhurst and Matfield (Kent) was made in 1931. These records and those taken in previous seasons show that, whereas the pathogenic organism is generally distributed throughout both the affected areas, the degree of damage due to this infection is closely correlated (i) with seasonal weather condition and (ii) with local soil conditions. A joint examination with the Kent soil survey of the soil of the affected gardens has been arranged.

" Fruit russeting " and " branch blister " disease.

Cultural work has been continued in an endeavour to identify various strains of fungi associated with these symptoms. The supposed causal organism is tentatively referred to the form genus *Coniothecium* (27), but diagnostic results are as yet inconclusive, as were those from numerous inoculations made in the spring with various strains of fungi in pure culture, in an attempt to show whether they are responsible for the symptoms shown by fruits and branches.

An investigation to test a possible relationship between vigour of tree and severity of fruit russeting (distinct from spray injury) indicated that the intermediate rootstock in some " double-worked " Cox's Orange Pippin trees showed no marked influence in this direction in 1931, when Bramley's Seedling and Stirling Castle were the intermediate stems concerned.

The results of spraying and dusting were inconclusive as regards fruit russeting in this particular season.

Fungicide trials.

Apple scab and apple mildew.—The results of a replanned spraying and dusting experiment on some 12 year old Cox's Orange Pippin trees confirmed those obtained in a previous experiment (26), in that three applications of lime-sulphur (" pink-bud," petal-fall, and three weeks afterwards) gave the most satisfactory control of these diseases. The single season's tests of post-blossom sulphur dusting gave promising results.

Certain data collected incidentally to those on apple scab on Cox's Orange Pippin showed that in 1931, as in 1930, the efficiency of a combined insecticide and fungicide against apple sawfly was greater than that of the same insecticide alone.

Pear scab.—An experiment designed to test the efficacy of Bordeaux mixture, of lime-sulphur, and of colloidal sulphur for the control of this disease was carried out on Fertility pear trees. Scab grading of the fruits (both thinnings, and those picked when matured) showed that there was little difference in efficiency between Bordeaux mixture and lime-sulphur at the strengths used, both giving very satisfactory control, and that colloidal sulphur was only half as efficient. Some rootstock influence on scab susceptibility was indicated.

Factors affecting susceptibility to apple scab and mildew.

Manuring, grassing down and rootstock were all shown, in 1931, to have exerted an influence on the degree of susceptibility to apple scab infection on Worcester Pearmain and Bramley's Seedling. Evidence was also forthcoming that these influences were not exerted independently of each other or of the weather conditions. With Cox's Orange Pippin previous indications of the influence exerted by the rootstock on scab and mildew susceptibility (26) were confirmed.

Diseases of walnuts.

Walnut bacterial blight.—After spraying an infected plant showing the marginal leaf spot with water from a fine nozzle for several hours on five successive days, typical leaf spots were produced on a clean seedling walnut placed below the infected plant. This suggests that the marginal spot precedes the typical infection, and that under natural conditions the bacteria are most probably washed from leaf to leaf during rain.

The disease appeared last spring on trees from which all bacterial lesions had been removed. Frequently all leaves from a single bud were attacked, thus suggesting that the organism may overwinter in the buds. To prevent spread of blight the importance of keeping a tree uninjured is emphasised.

The disease has now been found on two established walnut trees in England.

A disease following grafting.—This year many trees grafted in the spring failed to form a union. Numerous dark, powdery spores were seen at the cut surfaces between stock and scion. In culture smaller, hyaline, rod-shaped conidia also developed endogenously. In preliminary experiments the fungus grew well in all inoculated plants while the controls remained healthy. The parasite has been identified as *Chalaropsis thielavioides*, a fungus not previously recorded for Britain.

Fungi found on Walnuts in store.—Fungi found on shells were: *Penicillium* sp., *Botrytis cinerea*, *Cladosporium* sp., *Mucor* sp., *Rhizopus nigricans*, *Pachybasium* sp., *Fusarium* sp., *Coniothecium* sp., *Alternaria* sp., *Pestalozzia Hartigii*, *Stysanus Stemonites*. Fungi found on the kernels were: *Penicillium* sp., *Botrytis cinerea*, *Mucor* sp., *Rhizopus nigricans* (32).

ENTOMOLOGY.

The control of the fruit tree red spider.

A field spraying trial was carried out during the winter of 1930–1931 to test the value of a well-known petroleum oil against the eggs of the fruit tree red spider. The experiment was carried out on some badly infested plum trees growing at the Research Station, and the spray was applied at a strength of 10 per cent. in January.

Records obtained later in the season showed that the eggs of this mite were not killed by the petroleum spray, the hatch being similar on sprayed and untreated trees. This result confirmed observations made in growers' plantations in this and previous years. Further washes are being tested.

Woolly aphis.

The resistance of different rootstocks to woolly aphis attacks.—Still further modifications of the methods used for testing apple stocks and seedlings for their resistance to woolly aphis have been made during the year, and details of this work have been published (37). It has been found that quite young seedlings, with not more than two inches of growth, and contained in "Tom Thumb" pots, can be tested satisfactorily under glasshouse conditions. This saves a great deal of valuable space in the greenhouse, and allows more accommodation for testing a larger number of seedlings in any one year. Of 118 seedlings raised by Mr. M. B. Crane, of the John Innes Horticultural Institution, Merton, and tested at East Malling, three were found to be immune, while five were found to be very resistant to aphis attack. The remainder proved to be susceptible, many of them being killed as the direct result of aphis attack.

288 Spy crosses, raised by the Plant Breeding Section at East Malling, were also tested. Of this total 10 seedlings were found to be very resistant and will be retained for further tests next year. The remainder were susceptible to aphis attack, the degree of susceptibility not being very varied.

Causes of immunity.—Woolly aphides have now been successfully kept alive on artificial media for periods of up to 26 days, and details of this investigation have been published (21). The results suggest that the rate of reproduction of woolly aphides was more depressed by Northern Spy (immune) than by Allington Pippin (susceptible) extract (see also under Biochemistry, p. 92).

Woolly aphis parasite.—Renewed efforts to establish the woolly aphis parasite have been made in the Maidstone district of Kent. The parasites were introduced into a badly infested orchard, but they were not observed to effect any appreciable control upon the woolly aphis. The parasites were still active at the end of September, but it remains to be seen whether they will survive the winter or not. This work has been carried out in collaboration with the Plant Pathological Laboratory, Harpenden.

Apple fruit sawfly investigations.

Some new observations on the life-cycle of this insect have been noted in 1931. The adults have been observed emerging from the soil during the flowering period. The adults have also been observed depositing their eggs in the open flowers and not just below the calyx, which is the normal position for egg-laying.

The field spraying trials this season gave negative results, since the trees selected for the trials were not attacked by the apple fruit sawfly to any marked extent.

The field trials with nicotine dusts also gave negative results.

Black currant gall mite control.

The field spraying trial was continued with the object of ascertaining whether a better, non-scorching spray, other than lime-sulphur, could be used as a post-blossom spray on sulphur-susceptible varieties of black currants.

The sprays tested were colloidal sulphur, a two solution pyrethrum spray, a petroleum emulsion and lime-sulphur plus aluminium sulphate. The results obtained demonstrate that none of these sprays was superior to a pre-blossom lime-sulphur application. In fact all the post-blossom sprays caused considerable fruit and leaf injury.

Although the pre-blossom lime-sulphur spray may cause considerable leaf scorch on some varieties of the Goliath group, the crop records showed that the bushes which received the lime-sulphur treatment bear as many fruits as the untreated bushes.

Systematic study of gall mites.

The systematic study of the species of gall mites which occur on plums is being continued. In addition, the species of gall mites which occur on wild and cultivated blackberries are being studied. One species, *Eriophyes essigi* Hassan, has been found in this country for the first time. This species is of definite economic importance in the U.S.A., where it was first discovered.

The strawberry tarsonemid mite.

Recent investigations confirm the opinion that the strawberry tarsonemid mite (*T. fragariae* Zimm.) may cause serious damage to some varieties of strawberries growing under natural conditions. Three reports have been issued (36, 40, 41).

Plants infested with this mite exhibit typical symptoms of mite attack: malformed and crinkled leaves, the browning of young leaflets, and marked deterioration of the vigour of the plants. The leaves also become very brittle as the result of mite infection.

It has been ascertained that the intensity of mite attack may vary from season to season according to the climatic conditions prevailing. It has also been found that the runners become "naturally infested" from the parent plant, this infection taking place as soon as the runners commence to grow, and often before they are established on their own roots. Thus the necessity of selecting runners from healthy parent plants is imperative.

Identification.—Specimens have been received from different parts of the British Isles, America, Canada, and Holland. The British and Continental material proved to be identical (*T. fragariae* Zimm.) while the American and Canadian examples are found to be a distinct species, namely, *T. pallidus* Banks.

Life-cycle and habits.—More details of the life-cycle have been obtained, and experiments are in progress to find out whether the strawberry mite has an alternative host plant in this country; at present none has been discovered. In America *T. pallidus* Bks. attacks begonias, cyclamen and other plants, in addition to the strawberry.

Control measures.—Preliminary control measures have been started under laboratory and field conditions. Tests have been made with lime-sulphur preparations, petroleum oils and pyrethrum sprays. In addition, the treatment of plants by means of fumigation or by dipping them in hot water before planting is being investigated. At present the lime-sulphur preparations have been found the more effective in controlling the mite, and the practice of dipping runners in a 3 per cent. solution of lime-sulphur is to be recommended for commercial growers.

"Strawberry yellows."

Investigations are in progress in collaboration with the Mycological Section to determine whether the mite (*T. fragariae* Zimm.) is associated in any way with the strawberry disease described as "strawberry yellows." It has been found that the symptoms of the two diseases are quite distinct, but the association of this mite with plants exhibiting symptoms of "strawberry yellows" suggests that the mite may be a possible vector of the disease (see also p. 96).

The blackberry mites.

Observations on the life-cycle of the blackberry mite (*Eriophyes essigi* Hassan.) have been made during the summer. It attacks the cultivated blackberry, the cut-leaved blackberry, the Himalaya berry, the loganberry and also wild blackberries.

As soon as the fruits commence to develop they are attacked by this mite, and the result is a premature ripening of the fruits. This disease has been noted in America, and is described by the name of "redberry" disease. The mite has been reported from several localities in Kent during the present year, and may prove to be of definite economic importance.

The Mycology Section are carrying out experiments to determine whether a disease provisionally called "reversion" is caused by a transmissible virus. The constant association of *Eriophyid* mites with plants showing symptoms of "reversion" has been noted, and experiments will be carried out in collaboration with the Mycological Section to investigate the possible relation between the mites and the disease.

The apple blossom weevil.

Investigations are in progress with the object of obtaining a new type of corrugated cardboard band which will withstand our climatic conditions, and will not be attacked and destroyed by field mice, birds, etc.

Some types of coloured bands tested during the year proved most satisfactory, but further tests will have to be made before they can be recommended on a field scale. In addition, a number of bands have been treated chemically, with the object of finding out whether this treatment will render the bands distasteful to birds and field mice, but at the same time will continue to attract the apple blossom weevils. The preliminary trial gave very encouraging results.

Raspberry and loganberry beetle.

Observations made in the past season have thrown further light on the larval habits and may prove to have an important bearing on economic methods of control. A paper dealing with the bionomics of the pest is in the course of preparation.

Following the promising results of three seasons' preliminary spraying experiments, extended trials were laid down in 1931 on both raspberries and loganberries. The main objects were (a) to confirm certain observations made on the life history and thus to find optimum dates for spraying, and (b) to test the value of derris preparations against the larvae. A derris preparation has now for several years given very good control, in 1931 reducing the average infestation of loganberries from 66·3 to 14·6 per cent. and of raspberries from 78·3 to 5·6 per cent. The total weight of the loganberry crop was almost doubled, and the weight of marketable fruit increased from 23·8 to 77·7 per cent. by two applications of derris. Cost of spraying figures were obtained from a four-acre Lloyd George plantation which was sprayed commercially.

Promising results were obtained with a cheap home-made derris dust, and attention will now be given to the standardisation of such spray mixtures. A report on the season's work is awaiting publication, and previous seasons' work has been described in a progress report (39).

Insect transmission of raspberry mosaic.

An infection experiment with potted plants of two varieties (Lloyd George and Baumforth B.) has been carried out with two species of aphid (*Amphorophora rubi* Kalt. and *Aphis idaei* V.d.G.).

Capsidae.

A winter spraying trial, planned on statistical lines, against the apple capsid bug (*Plesiocoris rugicollis* Fall.) was carried out on a commercial farm. A considerable measure of control was obtained by the use of certain petroleum and tar-petroleum washes. The same sprays were also applied to strawberries, gooseberries and red and black currants to obtain information as to the damage likely to be done to undercrops where winter washing for capsid is employed. The significance of certain small differences remains to be examined before the results are published.

HOPS.

Commercial varieties.—Clonal races of the most important have now been established, and are available for experimental purposes.

Cultural trials.—Different distances for planting and the training up of various numbers of bines per hill are being tested on seedling L 21. The crop from these trials has now been recorded for the second season, and as the plots have now come into full bearing it was possible to obtain the weight of dried hops from each plot.

Very marked effects of the treatments on both the quantity of the crop and the size of the cones have been noted.

The question of the effect on the yield of the number of bines trained up each string is still rather doubtful, though, where one bine is trained up, the cones are markedly larger than in the case of two or three bines per string. Closer planting has again given the higher yields per plot, although the yield per hill is reduced by close planting. Where the hills are planted 3 ft. apart in the rows, the size of the cones is considerably reduced in comparison with 9 ft. and 6 ft. planting. It is intended to continue this trial over a period of years in order to discover whether the above results will be borne out under varying seasonal conditions, and with different varieties.

Half an acre of the seedling OP 21 (Oregon Cluster × English Male) × English Male has been planted this autumn and will be used for studying the effect of hard and light pulling of the bines combined with close and normal distance of planting. This trial will also provide material for brewing tests, and a source of sets for distribution to growers.

Another half acre of land has been planted with clone races of three strains of Fuggles and will be utilized for testing two degrees of severity of cutting the hills, as well as to ascertain if there is any variation in cropping of the "strains."

Manurial experiments in pot culture.—These experiments have been in progress for five years and have now been brought to a conclusion. Valuable and consistent diagnostic characters of foliage and growth closely associated with deficiency of certain elements of nutrition have been recorded. Mr. Burgess, of the South-Eastern Agricultural College, Wye, is kindly undertaking the chemical analyses of the plants grown under the various treatments. A report on the experiment is in preparation.

New seedlings.—Twenty-two of Professor Salmon's new seedlings have been planted out, and a corresponding number of varieties not worthy of retention have been grubbed to provide room for the new selections.

Nearly 200 seedlings were recorded and dried separately in 1931, and bottle samples for resin analyses were taken from over 100 varieties.

Of the early varieties in 1930, X 35 maintained its position in being richer in preservative substances than the Bramling. Amongst the midseason hops, seven varieties proved richer than the best commercial variety (Mathon) and three out of the seven had not been previously tested. In the late hops twelve varieties proved richer than the best commercial variety (Canterbury Golding). Three seedlings were of greater preservative value than the richest American hops; one of these varieties (C9a) has now exceeded the richest hops for three successive seasons. This work is being carried out in collaboration with Professor Salmon, who has issued a report (44), and Mr. Burgess, of the South-Eastern Agricultural College, Wye.

Several of the best of these seedlings are now being planted in bulk to test their suitability for introduction to commerce.

Incidence of downy mildew.—The wet season provided ideal conditions for the spread of the fungus, and the attack of the "spike" form of the disease in the spring and summer of 1931 was the severest yet recorded at East Malling.

"Spikes" first made their appearance at the beginning of May and continued to appear in large numbers throughout the summer until July 15th, when the gardens were sprayed with Bordeaux mixture. It was necessary to go round the gardens every week in order to keep the " spikes " removed. A feature of the season was the large number of spikes formed in the axils of the leaves during July.

Two sprayings with Bordeaux mixture were given (July 15th and August 12th) which gave a satisfactory control of the disease on the cones, except in the case of certain varieties with a large amount of " head " to their bines. A powerful blower is required in such cases.

Titles of papers issued during the year.

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2. *Annual Report*. II. Supplement. 1928-1930. Apr. 1931.

POMOLOGY.

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4. HATTON, R. G.: The elimination of sources of error in field experiments: the standardisation of fruit tree stocks. *Ibid.*, 13.
5. PAINTER, A. C.: An experiment in the thinning of Victoria plums. *Ibid.*, 74.
6. HOBLYN, T. N.: Field experiments in horticulture. *Imp. Bur. Fr. Prod. Tech. Com. No.* 2, 1931.
7. PAINTER, A. C.: An experiment in plum thinning. *E. Malling Res. Sta. Ann. Rep. for* 1930. I. General, 68, Apr. 1931.
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17. VYVYAN, M. C.: Course of growth in an apple stock during the maiden year. *E. Malling Res. Sta. Ann. Rep. for* 1928-30. II. Supplement, 85, Apr., 1931.

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22. Wormald, H.: Further studies of the brown rot fungi. V. Brown-rot blossom wilt of pear trees. *Ann. Bot.*, **44**, 965, 1930.
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MISCELLANEOUS.

43. Chapelow, H. C. and Tydeman, H. M.: Weather conditions during 1930. *E. Malling Res. Sta. Ann. Rep. for* 1930. I. General, 127, Apr., 1931.
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14. HORTICULTURAL RESEARCH STATION, CAMBRIDGE UNIVERSITY.

Plant Breeding.

The past season has on the whole been favourable to the work of the Research Station, conditions which are not welcomed by the market gardener being often of great assistance to the plant-breeder. For instance, the excessively wet weather experienced in Cambridge has, in the case of onions, made it possible to select strains which will ripen off well in spite of adverse conditions; and, since wet conditions favour the incidence of *Botrytis allii*, the selection of cultures showing a high degree of resistance to this fungus has been facilitated. In the case of Brussels sprouts, conditions have been ideal for the production of loose sprouts ("blowers") and thus the selection of plants with hard, non-blowing sprouts, suitable for breeding purposes has been simplified. Sprout plants in damp muggy seasons are liable to attacks of "leaf edge rot" and to a rot of the "knobs" themselves, bacteria, followed by *Botrytis* sp. being apparently responsible for the later stages of this trouble. Susceptibility to this rotting cannot be detected in a dry season, but the elimination of susceptible plants has been an easy matter this autumn.

A number of fresh problems has been considered. It has been suggested that the Station should attempt to produce (a) Brussels sprouts resistant to the club root fungus; (b) onions resistant to "onion smut" and "white rot"; (c) frost-proof white Lisbon onions; (d) celery which will resist the attack of *Septoria apii.* Since this question of disease-resistance is of great importance in the case of all the vegetables mentioned, work will be commenced (or has actually commenced) on all these problems.

The Station has also been consulted concerning (a) the possibility of growing profitably in this country beans of the Boston small pea type, the seeds of which are used for canning purposes; (b) the possibility of growing in England silver-skin onions and gherkins (for pickling), supplies of which have up to the present been obtained from abroad.

It is likely that these problems will involve plant-breeding work and all three will therefore be attempted.

A significant feature of the past season has been the interest shown by farmers in the possibility of growing market-garden crops, such as Brussels sprouts, as part of their rotation; and a revival of interest seems likely in the case of onions, on account of the better prices recently obtained for this vegetable.

It appears that, in the opinion of growers, much work remains to be done with cabbage and with hardy broccoli. Reliable stocks of cabbages of the Harbinger, Imperial, and Christmas Drumhead type are still needed by men who grow these types on a large scale. Late broccoli combining hardiness with high quality are also desired.

Beans (for canning).—A preliminary trial was given to a stock, " White Danubian," sent in by Messrs. Crosse and Blackwell. The season was very unfavourable to this type of bean and most of the plants failed to ripen their crop.

The stock proved to be a mixed one, and the plants raised varied in (a) size and shape of seed ; (b) height of plant ; (c) time of maturity.

Seed.—This ranged from beans the size of Henderson's White Marrow (an American variety) to beans no larger than the Boston Small Pea. In shape there were all grades between the typical kidney bean shape and the rounded, plump type represented by the Boston Small Pea.

Time of maturity.—Some plants failed to ripen a single seed, others ripened a few lower pods, and some produced a reasonably good crop of ripe seeds. No plant, however, was as early as the average French bean (represented in the trial by Vilmorin's " Phénix ").

Conclusions.—As far as could be seen in this preliminary trial, carried out in a cold, wet season, the stock would not have yielded a profitable crop of ripe seeds. On the other hand, it contained material (i.e., early maturing plants) which will be valuable for future breeding operations, and there appears to be hope of breeding a variety suitable for English climatic conditions.

Future work.—A further trial will be carried out in 1932. Meanwhile seed has been saved from selected plants, and if this gives good results breeding will be commenced.

Broccoli.—21 varieties were tested at the Station. Of these 12 were received from the Horticultural Organiser for Cornwall as strains of Roscoff type, 5 were seedsmen's stocks of Roscoff broccoli, the remainder being Angers types obtained from France. The conditions at the Research Station during the winter (alternation of hard frost with spells of damp, warm weather) wiped out the greater part of the trial. Here and there a plant of Roscoff type showed exceptional hardiness and succeeded in producing a good curd (a selection of these plants was saved and seeded on the Station), but the majority rotted away. The Angers types showed greater resistance to our weather conditions and one stock, " extra hâtif d'Angers " (Vilmorin), produced a fair proportion of marketable curds.

No further attempts will be made to grow Roscoff broccoli at Cambridge, except for the purpose of isolating hardy individuals for breeding purposes.

A trial of broccoli sent in by English seedsmen was made on the Middlesex County Council's Demonstration Station at Denham. The trial occupied an area of half-an-acre. One plant was found sufficiently good for breeding purposes.

The weather and soil conditions at Denham during the winter months were not favourable to broccoli and only a few of the stocks contained plants sufficiently hardy to withstand them.

In the spring of 1930 a selection of plants of Roscoff broccoli was made in Dorset and Hampshire from stocks which for some years had been grown under the supervision of Mr. Oldham (of the Ministry of Agriculture). These plants were transported to Cambridge and flowered under glass or in muslin enclosures. The plants under glass were crossed and selfed (incidentally it may be noted that of these nine plants only one proved to be self-sterile) and a good stock of seed was harvested.

A well-known broccoli grower (Mr. D. Walter, of Manor Farm, Hayling Island) offered to try out this seed on his farm and allotted to the Research Station a strip of two acres on one of his best fields. The plants were raised at Cambridge and despatched to him by road.

At the present moment the trial looks most promising and a selection (based on vigour, type, habit, disease resistance) has already been made. After the final selection (based, of course, on type of curd), plants will be removed to Cambridge for work under glass, while the remainder of the selected plants will be seeded where they stand. It is hoped that from these plants sufficient seed will be obtained both for future breeding work and for small scale distribution.

In view of the importance of the broccoli crop, special efforts are being made with this branch of the Station's work.

Brussels sprouts.—No trial of commercial varieties has been laid down this season, partly because of lack of space and chiefly because the material contained in the Station's own stocks is considered to be more suitable for breeding purposes than material from outside sources; moreover, there is already awaiting trial enough seed of the Station's own growing to plant up an area five times that of the present Research Station.

This season an acre of ground has been devoted to Brussels sprouts. In last year's Report it was suggested that continued inbreeding in certain lines might result in a decline of vigour. So far this expected decline has not taken place and further improvements have been made in the stock.

The work on Brussels sprouts may, genetically speaking, be regarded as being in its early stages, but from a commercial point of view it is at a fairly advanced stage; and, provided facilities for seed-growing and distribution were available, the seed of certain of our varieties could be put at the disposal of growers.

Cabbage.—Although a certain amount of work on cabbages has been carried out during the past four years it has chiefly consisted of ordinary mass selecting and trials of commercial varieties. Until recently no definite requirements had been formulated by any growers. During the past season, however, it has been discovered that a need exists for a true stock of Harbinger type, having a green heart, and for a true stock of Christmas Drumhead type.

Material for the Harbinger type has already been raised on the Station and will be further worked on; and suitable plants of Christmas Drumhead type have been marked down in a commercial culture and will be removed to Cambridge for breeding work.

The types of cabbage required by growers vary from district to district: some require a large cabbage for cutting early as "bag greens"; others require a small solid heart of high quality; others, again, require a medium size solid heart of Imperial type. Not all these problems can be attempted at present.

Cauliflower.—In last year's report mention was made of the excellent results obtained from seed saved from selected selfed plants, and it was stated that an effort was being made to save seed from the progeny of these selfed plants. The effort was successful, and this year the seed of these selected plants, or rather, of as many of them as could be accommodated on the limited space available, was tested. Again, the proportion of really valuable plants was so high that further selection had to be made and more seed saved, with the result that the state of affairs is now similar to that existing in the case of Brussels sprouts: far more seed is in hand than could possibly be tested in a single season on the Station, even if it were five times its present size.

Trials will therefore have to be arranged elsewhere. But in the case of cauliflowers this is not easy, since very high cultivation and a suitable soil are necessary for success.

The types from which seed has been saved are superior to the popular All the Year Round, having a more dome-shaped and a thicker curd, less leaf, and being (in the case of the earlier types) at least four weeks earlier (under Station conditions).

No tests were made of commercial varieties, since the trials last season (which included 18 varieties obtained from the best Continental sources) revealed no material more desirable than that bred on the Station.

Celery.—Seed was saved from plants selected from the Kirton trials and will be tested in 1932.

Lettuce.—Beyond further trials at Denham of varieties suitable for commercial work no further work has been done, exact information as to growers' requirements not being available. The seed harvest in 1930 was almost a complete failure owing to weather conditions. It is probable that an opening for the plant-breeder exists in the production of a lettuce which will not rot, or "go greasy," in a wet season, varietal differences as regards susceptibility to this trouble having been observed.

Onions.—Almost half an acre of our own strains, selections, and varieties was grown during the past season, most of the stocks having originated from bulbs selfed in 1924 or from material drawn from 1925 mass selections. Examination of the crop is not completed. A number of our stocks are suitable for commercial purposes and are being kept going until the problem of distribution to growers has been solved.

The objects of the work being carried out remain the same as those enumerated in last year's report, with certain additions. Among these additions are the production of onion varieties resistant to white rot, onion smut, and (in the case of white Lisbon) frost.

Parsnips.—Single plant selections are being continued. This has resulted in the elimination of the progeny of a large number of plants of the original mass selections, most of the stocks now being used having descended from a single plant.

The last crop harvested included many roots of a type which had hitherto not put in an appearance in new cultures. These were intermediates of a desirable character.

This season some of our stocks are being tested at the Station against a Bedfordshire stock and a stock from Wiltshire which has been selected by a grower for over 30 years. The crop, of course, is not yet lifted.

Indications have appeared that certain types of root are resistant to "parsnip canker."

Peas.—Work with peas this year was rendered extremely interesting by a very severe outbreak of pea mosaic. This enabled us to eliminate a number of cultures showing susceptibility to this trouble and to isolate others which were apparently unaffected (though growing side by side with infected cultures).

An interesting feature of the trials of a number of F_4 cultures was that certain of them were practically untouched by thrips, or pea midge, while others (side by side with them) were badly attacked.

A large number of peas (some harvested in 1929) still remains unexamined, but it is hoped that when more assistance is available this work will be continued.

Two varieties (raised at the Station) which were considered to have possibilities as canning peas were sent up for trial at the Campden Fruit and Vegetable Preservation Research Station. The report on these varieties has not yet been received.

Strawberries.—A number of promising seedlings fruited this season. These, together with seedlings considered to be of value the previous season, have been propagated on as large a scale as space allows.

A large batch of seedlings resulting from crosses made during 1930 was planted out this year, and fresh crosses were made. No more space for this work is, however, available on the Research Station.

CHEMISTRY.

Spraying, etc.—Work on the physical chemistry of spray fluids has been continued. It has been shown that, in using emulsions against insect pests and eggs, the perfect stable oil-in-water type alone is suitable and safe. An imperfect emulsion or one of the water-in-oil type is dangerous to plants, and hence must be avoided. Lecithin should be added to the list of emulsifiers ruled out on this account.

One important class of sprays can be excepted from the above rule. Emulsions used as weed killers need not necessarily be perfect, and may be of the water-in-oil type, as free oil helps the phytocidal effect. Thus it has been shown, in conjunction with Mr. Wiley, that a wash containing cresylic acid and aqueous arsenic acid with glue as emulsifier, used in the eradication of prickly pear, is of the water-in-oil type (1).

The use of sulphur suspensions is becoming increasingly widespread. A study of the physico-chemical properties of these suspensions has been commenced, special attention being devoted to particle size, stability, and amount of protective colloid.

A report has been issued on the incompatibility of fungicides and insecticides, and of spreaders and emulsifiers with the toxic agent of the spray fluid and with hard waters (2).

Comparison of various weed killers, particularly against wild onions arising from bulbs and bulblets, has been made with the aid of Mr. W. A. Jones. Spreaders were incorporated with the sprays in the hope of wetting the onions (3).

Conjointly with Dr. Taylor and Mr. Hanley, a report has been published on a successful attempt at ameliorating soil conditions in a greenhouse where sodium clay was predominant as a result of the continued use of brackish water (4). With Mr. Chapman, a continuation of the work on certain properties of clays derived from bentonite has been made.

PESTS AND DISEASES.

Mycology.—A damping-off of brassica seedlings due to *Rhizoctonia* sp. was investigated. Cheshunt compound as ordinarily used failed to control the disease, but excellent control was obtained by the use of 1/1,000 mercuric chloride.

A wilt disease of strawberry plants which is causing considerable losses locally in the King's Lynn district and at the Horticultural Research Station is under investigation. The disease appears to be due to a species of *Verticillium* which is constantly found in the attacked plants, but the results of inoculation experiments are not yet available. Soil sterilisation and manurial trials, both with pot plants and in the field, are in progress.

Ten varieties of Brussels sprouts were grown on land heavily infected with club root. None was immune, every plant on the plot being attacked. But a few varieties were able, possibly owing to the wet summer, to produce moderate crops in spite of the fungus attack. There seems to be some correlation between the vigour of the variety and this tolerance of the disease. Seed box trials under controlled conditions, as well as a further field trial, will be carried out with these varieties.

During next season, work on the Marssonina ring-spot of lettuce and on onion white rot will be undertaken.

Entomology.—Investigations are in progress on the second generation of the carrot fly *Psila rosae,* in co-operation with Mr. F. R. Petherbridge. A muslin cage was erected on the headland of a 10-acre field of carrots at Somersham and visited at short intervals from August 12th onwards, a record being kept of all insects collected in the cage at each visit.

The results of the experiment suggest the use of deterrents in August and September at the period when the second generation of carrot flies may be expected to be most in evidence.

The experiment will be repeated next season, using several cages.

It is proposed to carry out investigations with the onion and cabbage root flies during the coming season.

Titles of papers issued during the year.

1. Woodman, R. M., and Wiley, W. J.: The eradication of prickly pear by chemicals. *J. Soc. Chem. Ind.*, **50**, 22, 183 T, 1931.
2. Woodman, R. M.: The incompatibility of fungicides and insecticides, etc. *N.F.U. Yr. Bk.*, 401, 1931.
3. Woodman, R.M., and Jones, W. A.: Eradication of weeds by chemicals. *Chem. News and J. of Industrial Service,* **144**, 21, 1932.
4. Taylor, E. McK., Woodman, R. M., and Hanley, F.: A note on the reclamation of a greenhouse soil containing sodium clay. *Chem. News and J. of Industrial Service,* **143**, 309, 1931.
5. Woodman, R. M.: An examination of some commercial suspensions used in spraying. *J. Soc. Chem. Ind.*, **50**, 391 T, 1931.

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15. EXPERIMENTAL AND RESEARCH STATION, CHESHUNT.

Manurial and Crop Management Trials.

Tomatoes.

Manurial and crop management trials with tomatoes have been continued. The experiments relating to the relative effects of different nitrogenous fertilisers were adversely affected by an attack of wireworm, but there were indications that organic forms of nitrogen are more effective on tomatoes than the inorganic forms. Finely ground hoof and horn and fish manure gave the highest yields in this series during the season.

The experiment in which some plants were " stopped " at the fifth truss and others allowed to continue vertical growth unchecked has been repeated over a period of years, and previous results are confirmed, namely that the heaviest crop results from unchecked growth, and, while picking commences some three to seven days earlier from the " stopped " plants, the weight of fruit gathered by the end of June is similar in each case.

Houses which were steamed for 1931 showed a crop increase of 24 per cent. over the control, while treatment with formaldehyde gave little response. The latter result may be associated with the unsuitable weather conditions which prevailed. The addition of old tomato roots to soil previously steamed reduces the yield some 9 per cent., the harmful effect being noticed after the end of June.

A good type of Sphagnum peat incorporated with the top twelve inches of soil after steaming proved beneficial, and increased the yield 14 per cent. over that obtained from steaming alone. When added in a similar manner to soil previously treated with formaldehyde the crop increase was only 4 per cent. An excellent result, probably of considerable significance, was obtained by digging clean chrysanthemum roots into a plot previously steamed. A yield of 55 tons per acre was recorded being equal to the crop obtained from this plot during the first year of cultivation. The use of plain wheat and oat straw applied at the rate of three tons per acre to the top spit and a similar quantity to the second spit has proved useful in several nurseries and is worth further trial, especially in old nurseries.

The liming experiments have been continued with results similar to those obtained previously. It would seem that the value of lime for tomato soils has been over-estimated, except in cases where it is necessary to improve the tilth. The variety trials included a number of new crosses, of which Tuckswood × E.S. 1. proved the best. The work of breeding good cropping varieties resistant to " leaf mould " is being continued, and certain stocks have been selected for trial on a larger scale next year.

Through the kind co-operation of Messrs. Shell Mex Ltd., who installed a completely automatic oil-fired boiler at the Station, it has been possible to examine this form of heating for glasshouse work. Excellent temperature control was observed, and there are indications of increased crop production and greater freedom from "leaf mould" being obtained by this method.

Temperature investigations of the soil and air have been continued during the current year, and have shown that, although under normal heating conditions in glasshouses the optimum temperature for tomato growth is about 63° F. to 65° F., the crop yield can be appreciably increased by increasing the air temperature to 68° F., when the temperature of the soil is also raised to approximately the same degree.

A method of heating the soil for tomatoes by buried pipes through which hot water is circulated has been tested. Although maximum temperatures of 90° F. were obtained, the crop increase was not appreciably above that obtained when the soil temperature was maintained about 80° F.

Leachings from tomato soil.

By means of a drained concrete tank in one of the tomato houses the examination of drainage water has been commenced, to determine the composition of the leachings from tomato soil and the fluctuations in the composition. The information so far obtained indicates that appreciable losses occur in this way of potash and nitrogen (chiefly as nitrate). Only the faintest traces of phosphates have been found in the drainage this year, and on no occasion were nitrites detected in measurable amounts. It appears likely that the heavy falls in the nitrate content of a tomato soil, already recorded in earlier reports, are largely due to leaching.

Cucumbers.

The cucumber experiments were designed to test the effect of reinforcing the normal beds of soil and stable manure with a proportion of plain wheat straw. The effect on heavy virgin loam was compared with that when baked old cucumber beds were used.

As in previous years, the crop was improved by rendering the bed more open by occasional top dressings of plain straw. Good crops were grown in beds composed of baked old cucumber beds and straw only, but the virgin soil did not contain sufficient nitrogen and required some stable manure in addition to the straw.

No improvement in crop production was observed from the addition of peat to the beds.

Preliminary experiments with heating cucumber beds to a temperature of 85° F. have indicated that the yield can be increased by 50 per cent. while the heating continues.

Lettuce.

Golden Ball and Tom Thumb lettuce have been grown successfully during the past four years as a catch crop before tomatoes. The young plants are set out in unheated houses during December, leaving room to plant tomatoes between the rows. The lettuce crop has been removed within four or five weeks of planting tomatoes.

PESTS AND DISEASES.

The Red Spider investigations have been continued and the use of a sulphonated oil product as an alternative to petroleum oil emulsion sprays for controlling this pest has been investigated. When used at a spraying strength of 1 part in 250 parts of water by volume, complete control of the mite was obtained with no damage to tomato or cucumber plants even after repeated application. When used at this strength the cost is approximately one half that of the ordinary petroleum oil emulsions, whilst the tendency to cause *Oedema* appears less pronounced.

The examination of different series of chemically related compounds with regard to their action as fumigants has been continued, and previous findings regarding the effect of molecular structure have been confirmed. In the presence of plants there is a considerable reduction in the toxicity of the higher members of the methyl-esters of the fatty acid series which reduces their potential value below that of methyl formate.

The breeding and distribution of the white fly parasite, *Encarsia formosa*, Gahan, has been continued. The demand for this material continues to be as great as in former years. The larvae of the cucumber root flies, *Plastociara perniciosa*, Edw., and *Pnyxia scabiei*, Hopk., caused considerable damage to commercial crops. Reasonable control of these pests in beds has been obtained by thoroughly drenching the soil with nicotine in a sulphonated oil.

The use of Salicylanilide in the form of a 50 per cent. paste (known as Shirlan paste) in conjunction with Agral 1, has been tested and established on commercial nurseries as a control of tomato leaf mould, caused by *Cladosporium fulvum*.

Virus disease.

Mosaic disease investigations have been continued, and the importance of clean seed has been emphasised.

The effect of the virus on the metabolism of the tomato plant has been studied. Preliminary results suggest that under conditions of high temperature and light intensity there is at first an increase in the carbohydrate content of tomato plants infected with aucuba mosaic, followed by a reduction. During the winter, when the light intensity is low, the period of carbohydrate increase is greatly prolonged.

A form of this disease known to growers as " peppery stripe " has proved to be the result of infection with a mixed virus. Comparative studies with this disease and " Stripe " disease have been started.

Title of paper issued during the year.

1 Owen, O.: The analysis of tomato plants. II. The effect of manurial treatment on the composition of tomato foliage. *J. Agric. Sci.*, **21**, 3, 1931.

16. JOHN INNES HORTICULTURAL INSTITUTION.

The work of this Institution deals with fundamental problems of plant behaviour in reproduction. In the following directions contact is made with the practical work in agriculture and horticulture.

Several investigations in progress bear on the origin of cultivated plants. Mr. Moffett in his papers (21, 22) derives the Pomoideae, with a chromosome number of $n=17$, from a stable rearrangement (" secondary balance ") of the number $n=7$ found generally in the less differentiated sub-orders of the Rosaceae. Mr. Lawrence has put forward a theory of the origin of the garden Dahlia (19), which is an octoploid, by twice repeated chromosome doubling from ancestral diploid forms no longer in existence. His cytological observations are supported by extensive breeding work.

In both cases the cytological evidence turns on the observation of " secondary association " of the chromosomes at metaphase and anaphase. Mr. Lawrence suggests tentatively, on the basis of published figures, that " secondary association " is a widespread phenomenon. In some cases, as originally suggested for *Pyrus* by Mr. Darlington and Mr. Moffett, the plants in question are " secondarily balanced " polyploids with rearranged chromosome numbers ; in others they are orthopolyploids whose constitution is not evident from chromosome number alone, as their presumed diploid ancestors are no longer to be found. Earlier workers apparently ignored the evidence of secondary association in their anxiety to obtain division plates with the chromosomes spread out as widely as possible. This work has a practical bearing in that the breeding behaviour of such disguised polyploids (some of which are important cultivated plants) may differ from that of simple diploids.

In collaboration with Mr. J. W. Gregor of Corstorphine, Mr. Sansome has investigated the grass *Phleum* (" Timothy ") (27). He finds that in the forms aggregated under *P. pratense* the strong-growing American type is hexaploid, the native type diploid. In the related *P. alpinum* tetraploid and diploid forms are found. A synthetic hexaploid was obtained by doubling of the chromosome number occurring in the triploid F_1 of the cross between *P. pratense* diploid and *P. alpinum* tetraploid, and it is suggested that the American *P. pratense* may have originated in a similar way.

Mr. Crane gave a summary of his results on fruit pollination at the International Horticultural Congress (6), and has also published a paper on the relation between incompatibility and polyploidy in cultivated fruits (7), showing that there is an inverse correlation between the frequency of incompatibility on the one hand and chromosome number and complexity on the other. In collaboration with Mr. Lawrence an account is given of breeding results with raspberries (8). It is of interest that sex behaves as a two-factor Mendelian case, the factors causing maleness and femaleness respectively. The two dominant factors together give a hermaphrodite, while the corresponding double recessive plant is neuter.

Mr. La Cour (17) gives details of the new fixatives for plant cytological and other refinements in technique which he has introduced into the routine of the Institution.

Titles of papers issued during the year.

1. Andersson—Kottö (I.): Variegation in three species of ferns. *Z. indukt. Abstamm.- u. Vererb Lehre* **56**, 115, 1930.
2. Anderson, E., and De Winton, D.: The genetic analysis of an unusual relationship between self-sterility and self-fertility in *Nicotiana. Ann. Missouri Bot. Gard.* **18**, 97, 1931.
3. Andersson-Kottö (I.): The genetics of ferns. *Bibliogr. Genet.* **8**, 269.
4. Buxton, B. H. and Darlington, C. D.: Behaviour of a new species, *Digitalis mertonensis. Nature* **127**, 94, 1931.
5. Cayley, D. M.: The inheritance of the capacity for showing mutual aversion between mono-spore mycelia of *Diaporthe perniciosa* (Marchal). *J. Genet.* **24**, 1, 1931.
6. Crane, M. B., and Lawrence, W. J. C.: Studies in sterility. *Rep. 9th Int. Hort. Cong.* 100, 1931.
7. ———— ————: Sterility and incompatibility in diploid and polyploid fruits. *J. Genet.* **24**, 97, 1931.
8. ———— ————: Inheritance of sex, colour and hairiness in the raspberry, *Rubus idaeus* L. *Ibid.*, **24**, 121, 1931.
9. Darlington, C. D.: Chromosome studies in *Fritillaria*. III. Chiasma formation and chromosome pairing in *Fritillaria imperialis. Cytologia* **2**, 37, 1931.
10. ————: Meiosis in diploid and tetraploid *Primula sinensis. J. Genet.* **24**, 65, 1931.
11. ————: Cytological theory in relation to heredity. *Nature* **127**, 709, 1931.
12. ————: Meiosis. *Biol. Reos.* 6, 221.
13. ————: The cytological theory of inheritance in *Oenothera*. *J. Genet.* **24**, 405, 1931.
14. De Winton, D., and Haldane, J. B. S.: Linkage in the tetraploid *Primula sinensis. Ibid.*, **24**, 121, 1931.
15. Haldane, J. B. S.: A mathematical theory of natural and artificial selection. VII and VIII. *Proc. Camb. Phil. Soc.*, **26**, 131, 137, 1931.
16. ————: Prehistory in the light of genetics. *Roy. Inst.*, 1931.
17. La Cour, L.: Improvements in everyday technique in plant cytology. *J. Roy. Micr. Soc.*, **51**, 119, 1931.
18. Lawrence, W. J. C.: Incompatibility in polyploids. *Genetica.* **12**, 269.
19. ————: The genetics and cytology of *Dahlia variabilis. J. Genet.* **24**, 257.
20. ————: Mutation or segregation of the octoploid *Dahlia variabilis? Ibid.*, **24**, 307.
21. Moffett, A. A.: A preliminary account of chromosome behaviour in the Pomoideæ. *J. Pomol.* **9**, 100.
22. ————: The chromosome constitution of the pomoideæ. *Proc. Roy. Soc.* B **108**, 423.
23. Newton, W. C. F.: Genetical experiments with *Silene otites* and related species. *J. Genet.* 24, 109, 1931 (prepared by F. W. Sansome).
24. Philp, J., and Huskins, C. L.: The cytology of *Matthiola incana* R. **Br.** especially in relation to the inheritance of double flowers. *Ibid.*, **24**, 359, 1931.
25. Sansome, F. W.: Saxifrage crosses. *Nature.* **127**, 59.
26. ————: Graft hybrids and the induction of polyploids in Solanum, *Rep. 9th Int. Hort. Cong.*, 92, 1931.
27. Sansome, F. W., and Gregor, J. W.: Experiments on the genetics of wild populations. II. *Phleum pratense* L. and the hybrid *P. pratense* L. × *P. alpinum* L. *J. Genet.* **22**, 3.

D.

ENTOMOLOGY
and
PLANT PATHOLOGY.

17. PLANT PATHOLOGICAL LABORATORY, MINISTRY OF AGRICULTURE AND FISHERIES.

The activities of this laboratory are primarily concerned with questions arising out of the administration of the Destructive Insects and Pests Acts, with advisory and educational work, and with any other matter relating to the diseases and pests of plants in which the Minister may be concerned. Research is carried out only in so far as other duties permit, and it is frequently of a co-operative nature, the function of the laboratory being to act as a connecting link between different research stations or advisory centres; in this latter case, the work is reported upon by the stations or centres concerned, and no attempt is made here to give a comprehensive account.

Pyrethrum investigations.—Crops of pyrethrum flowers have again been successfully harvested, dried and sold from the large plots to which reference has previously been made. These include three plots giving their second harvest of flowers, and two which have cropped for the first time this year. Yields were rather below those obtained last year, probably owing to less favourable weather conditions. As already noted, costings figures are being kept for these plots, which it is hoped to continue for several years.

Further supplies of seed for small scale experiments have been forwarded to several Dominions and Colonies, and interesting preliminary reports have been received from the Government Entomologists in Kenya Colony and in Tanganyika Territory as to the progress of experiments with pyrethrum plants grown from seed sent in previous years. Evidence is accumulating that pyrethrum is not likely to flourish under fully tropical conditions, but the reports indicate that the crop may succeed in certain areas of high altitude in Kenya, and further experiments are in hand.

The small plots at the Ministry's Laboratory have again cropped well, and a quantity of seed has been saved which is available for further experimental work. Laboratory investigations on the content and yield of the insecticidal principles in individual plants and strains has been continued in collaboration with the Insecticide Department at the Rothamsted Experimental Station.

Evidence has been obtained suggesting that pyrethrum is relatively self-sterile, and crosses have been made between plants showing high productivity with a view to developing a better strain.

A short article summarising the position of investigations in Great Britain on pyrethrum as an insecticide was contributed to "Nature" in April, 1931 (1).

Potato sickness.—The investigations referred to in the previous report were concluded. It was found that the sickness did not occur in the absence of the eelworm *Heterodera schachtii*, but on the other hand that potato plants may grow normally, even when heavily attacked by the eelworm; and no correlation was found between the cyst content of the soil and the intensity of the sickness. There was no reason to suspect that the fungus *Corticium Solani*, or any other parasitic organism (apart from the eelworm) played any primary part in causing the sickness, and the evidence suggested that the sickness is due to an attack by the eelworm, coupled with a soil factor that prevents a vigorous early growth of roots: it is possible that this soil factor may be a nutritional defect which is not made good by the ordinary manurial measures in use in potato-growing districts (3).

Aphelinus mali.—Further introductions of the woolly aphis parasite were made during 1931, but the wet season proved very unfavourable for its spread, and it is doubtful whether the parasite made any progress (4).

Strawberry moth (*Acalla comariana*).—Advantage has been taken of epidemics of this species to obtain some insight into the problem of polymorphism (5).

Bulb diseases.—Co-operative experiments with some of the Advisory Officers are being undertaken with a view to confirming or disproving the opinion held by growers that root plate rot of narcissus can be controlled by lifting and planting affected bulbs in fresh soil. Special attention has also been devoted to gladiolus diseases, which appear to be on the increase.

Mahonia rust.—A North American rust (*Puccinia* (*Uropyxis*) *mirabilissima*), the complete life-cycle of which is confined to this shrub, was encountered during the year in four or five counties, and was at first thought to be quite new to England and Wales, although it had previously been noted in Scotland. Investigation showed that this rust had been collected in North Wales in 1926, but had remained unidentified. Although not absolutely new, therefore, it must be regarded as a quite recent introduction into this country. In recent years the rust has also been discovered in many localities on the Continent, and Mahonia consignments thence to this country have, on one or two occasions, been found to be affected with the new rust and have been intercepted and destroyed (6).

Seed-borne diseases.—Examination of seeds, destined for export to certain countries, for the purpose of the issue of the necessary health certificates, was continued, and the diseases most commonly met with were leaf and pod spot of peas (*Ascochyta Pisi*) and the leaf spots of celery and parsley (*Septoria Apii* and *S. Petroselini*). An article dealing with the transmission of plant diseases by seed was prepared and published (7).

Bacterial plant diseases.—The services of Professor S. G. Paine have continued to be retained for special work on bacterial diseases of plants, and studies on the infection of Manetti rose stocks with crown gall (*Bacterium tumefaciens*) have been further advanced. It is becoming clear that many of the abnormal growths on these stocks hitherto regarded as being due to infection with this organism are in reality merely callus over-growths. Studies of a bacterial canker of apple trees have been completed and an account of them published (8). Special investigations on the green-fluorescent group of bacteria have been in progress for some time, and the first of a series of papers dealing with them has recently been issued (9).

Miscellaneous.—Several fungi, not previously recorded in this country, have been observed during the period under review. Among them may be mentioned the short-cycled Orange Rust of Rubus, *Kunkelia nitens*, on cultivated dewberries, *Corticium centrifugum* on apples imported from America, *Oidium Hortensiae* on hydrangea, *Sclerotium rhizodes* on *Agrostis vulgaris* and other grasses, a species of *Sphaceloma* on rose leaves, and *Chalaropsis thielavioides* on carrots, previously recorded only on lupins in Italy and Germany. In addition, *Glomerella cingulata* was observed causing Ripe Rot of grapes—a new host record for this country—whilst a fungus, not yet fully identified but agreeing closely with the description of *Stagonospora Fragariae* Briard. and Har., was found associated with a previously unreported leaf and fruit spotting of strawberries.

Titles of papers issued during the year.

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4. Fryer, J. C. F.: Some beneficial insects. *Bull. No.* 20, *Min. Agric.*, 1930.
5. ————: Further notes on the tortricid moth *Acalla comariana* Zeller. *J. Genet.* **24**, 2, 195, 1931.
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7. ————: Transmission of plant diseases by seed. *Encyclopædia of Scientific Agric.*, **2**, 1089, 1931. Baillière, Tindall and Cox, Lond.
8. Lacey, M. S., and Dowson, W. J.: Studies in bacteriosis. XVIII. A bacterial canker of apple trees. *Ann. Appl. Biol.* **18**, 30, 1931.
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18. POTATO VIRUS DEPARTMENT, PLANT BREEDING INSTITUTE, CAMBRIDGE UNIVERSITY.

Whilst the primary object of the Department has been the raising of healthy and, as far as possible, virus-free stocks of the main varieties of the potato, its work has been at all times closely allied with pure research on virus diseases (1). Even a brief summary of the Department's activities during the last five years must, therefore, take account of both aspects of its work.

Raising of virus-free stocks.—The Department has in its possession stocks, which are free from all demonstrable virus diseases, of the following varieties: Abundance, Arran Banner, Arran Chief, Arran Comrade, Arran Crest, Arran Victory, Epicure, Great Scot, Kerr's Pink, Majestic and President. The 1931 field plots were practically free from all inherited disease and there was little evidence of seasonal infection. All plots were rogued. In addition, the Department has stocks of Champion, Golden Wonder, King Edward and Uptodate which, whilst certainly carrying disease, are possibly the most healthy-looking and luxuriantly growing stocks of these varieties to be found anywhere. In addition, stocks of Duke of York, Eclipse, and May Queen are being worked up.

It has been found that King Edward harbours a peculiar disease, paracrinkle, which is very harmful to certain other varieties. Over 150 stocks of King Edward from all parts of Great Britain have been tested, and all were found to contain the disease, though they themselves appear quite healthy. It follows that King Edward should never be planted alongside other varieties.

The problem of multiplying these stocks and developing methods by which they might be profitably used in commercial potato-growing in the Eastern Counties is now being worked out.

One of the chief results of this year's work has been the discovery of a virus which has been called the "Z" virus which, like Dr. Kenneth Smith's "X" and "Y," enters into the composition of many of the virus diseases. Syntheses have been made of combinations of the Z, X, and Y, in varying arrangements, with the result that several of the clinical diseases have been reconstructed. Evidence has also come to hand that certain groupings of the virus diseases within a plant may lead to a condition equivalent to that of a carrier. On the other hand, there is evidence that carriers can, by the dissociation of the virus complex which they carry themselves, evince the symptoms of disease (4).

The "streak" diseases have been investigated both clinically and histologically and four distinct types of streak have been recognised.

The cytological examination of virus diseases by Dr. and Mrs Hurst has now been completed, and a report will shortly be ready for publication.

The work of the Head of the Department and Miss O'Connor on the problem of raising potatoes genetically resistant to the common blight has been continued (3, 5), and the Station has in hand some dozen seedlings which are practically immune. These will be tested further for their economic worth, but in addition to that they afford a valuable nucleus as potential parents bearing a highly desirable character.

Entomology.—The following facts of importance have been elucidated in the work:

(a) The mosaic diseases of the potato have been found to consist, as a rule, of a complex of viruses, and not, as has been thought hitherto, of single entities (9, 12). Two viruses have been isolated in pure culture and provisionally named X and Y, where Y is aphis-borne and X is not so transmitted ; both are transmissible by needle scratch. A method of virus isolation from a complex in the living plant has been elaborated.

(b) The tomato virus known in Australia as "spotted wilt" has been discovered in England and its identification with an indigenous ring-spot virus proved (7). The insect vector in this country has been proved to be *Thrips tabaci* (10). Studies are being carried out to prove a possible connection between spotted wilt and tomato "streak" or "stripe." The spotted wilt virus has been shown to have a wide host range. In addition to the tomato and the potato, it has been experimentally transmitted to such widely different plant hosts as dahlias, asters, zinnias and plaintains.

Titles of papers issued during the year.

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2. ———: Les maladies à virus de la pomme de terre. Leur analyse et leur synthèse. *Rapports du Deuxième Congrès International de Pathologie Comparée,* Paris. **1**, 1931.
3. ———: Récent progrès dans la création de variétés de pommes de terre résistant au "mildiou" (*Phytophthora infestans*). *Ibid.*, **2**, 1931.
4. ———: The analyses and syntheses of some diseases of the mosaic type: the problem of carriers and auto-infection in the potato. *Proc. Roy. Soc., B.* (In the press.)
5. SALAMAN, R. N., and O'CONNOR, Miss C.: Recent progress in the breeding of varieties resistant to blight. *Brit. Assoc. Adv. Sci.*, Lond., 1931.
6. SMITH, K. M.: A *textbook of agricultural entomology. Camb. Univ. Press.* Feb., 1931.
7. ———: Studies on potato virus diseases. VIII. On a ringspot virus affecting solanaceous plants. *Ann. Appl. Biol.* **18**, 1, 1931.
8. ———: Studies on potato virus diseases. IX. Some further experiments on the insect transmission of potato leaf roll. *Ibid.*, **18**, 2, 1931.
9. ———: On the composite nature of certain potato virus diseases of the mosaic group. *Nature.* May 9th, 1931.
10. ———: *Thrips tabaci* Lind. as a vector of plant virus disease. *Ibid.*, June 6th, 1931.
11. ———: Virus diseases of plants and their relationship with insect vectors. *Biol. Rev.* **6**, 3, 1931.
12. ———: On the composite nature of certain potato virus diseases of the mosaic group as revealed by the use of plant indicators and selective methods of transmission. *Proc. Roy. Soc. B.* **109**, 1931.

19. BIOLOGICAL FIELD STATION, IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY.

Survey work.—The study of the temperature and humidity conditions prevailing at Metropolitan Wharf, Cook's Wharf, Millwall, and Port of London Authority Dock No. 10, has been continued. This work is carried out in conjunction with a study of the life history under dock conditions of the moth *Ephestia elutella* and *Plodia interpunctella*.

Recording hygrometers used in this work have not proved very suitable and hair hygrometers have replaced them.

The study of the life history of the moths above mentioned has proceeded satisfactorily. The duration of the various stages in the life history has been determined in general and detailed work on individual insects is now in progress. At Millwall and Port of London Authority Docks, the total life history is 14 days shorter than at Metropolitan Wharf and this corresponds with a mean temperature at Metropolitan Wharf lower by 5° F.

The question of re-infestation of cocoa in store has been studied.

Dried fruit inspections in co-operation with Dr. Nicholson of the Commonwealth Council of Science and Industry in Australia has been continued. Definite evidence that the condition of the packing sheds has a direct bearing on infestation of fruit on arrival has been obtained by comparing Dr. Nicholson's reports on the packing sheds with our reports on inspection of fruit on arrival. This is a most important point, as we have long believed that conditions in Australia affected conditions in England.

The general survey of insect infestation of produce has been extended and 18 wharves are now regularly visited as compared with 10 last year.

Mycological survey work has made good progress and a report on the sampling of West African cocoa arriving at Liverpool has been completed. A preliminary report on this survey is in preparation. One important point has emerged from this survey, namely that the development of moulds in cocoa beans is directly dependent on high moisture content after preparation and before shipment.

Numerous enquiries regarding moulds have been received, these being concerned with tobacco, cheese and butter, rubber, hides and skins.

Research and experimental work.—The research work on the factors affecting fertility in *Ephestia* and *Plodia* moths has been continued. It is now well established that high temperature is a cause of infertility by acting on the male moths. A study of the effect of humidity and of composition of the food is in progress. As has been previously reported this work is of great importance in relation to the rearing of insects for experimental work, as well as being of high scientific interest.

The rearing of insect stocks proceeds satisfactorily and although our methods are open to improvement they are now proving fairly adequate for our purposes.

Studies of high lethal temperatures have been made in regard to *Ephestia elutella* and *Ephestia kuhniella*. The most important results of these show that eggs are highly resistant as are also pupae and that there is considerable range of variation in resistance among different individuals in the same stage of development. This work again is of high practical value.

Mycological work in the laboratory has been concerned mainly with the isolation and identification of moulds on copra, cocoa, rubber, tobacco and butter. It is satisfactory to be able to report that for the furtherance of work on the taxonomy and physiology of moulds a grant in aid has been received from the Department of Scientific and Industrial Research. This will relieve Mr. Bunting of much routine work and enable him to extend his range.

Research work on fumigants has made slow but good progress and a report on the vapour pressures of gases used in admixture is ready for publication. The new fumigation chamber so long delayed for lack of adequate electric power supply is now almost completed. Once this chamber is in working order progress should be rapid.

Special attention has been given to the use of ethylene oxide as a fumigant and this subject is now occupying a considerable part of Dr. Page's time.

General.—Apart from survey, experimental and research work, good progress has been made in other directions. Professor Munro has attended meetings of the Joint Committee on Cocoa Infestation, recently appointed by the London Cocoa Association and the Confectioners' Alliance. He has also discussed with the leading wharfingers and with Imperial Chemical Industries Ltd., the general question of sterilization of food products.

A special experiment in the fumigation of cocoa by hydrocyanic acid gas was carried out at Metropolitan Wharf in June, in co-operation with Mr. Macara representing the Confectioners' Alliance and the cocoa manufacturers.

On the whole it may be said that interest in the stored products work is increasing satisfactorily and that progress on the practical side of the work may soon be expected.

Tobacco infestation.—The investigation of infestation of tobacco in store by *Ephestia elutella* begun last year by means of a grant derived partly from the Empire Marketing Board and partly from the Southern Rhodesian Government, has been continued. The investigation is however now wholly supported by the Southern Rhodesian Government and the Imperial Tobacco Company. Good progress has been made in this work.

20. PLANT PATHOLOGICAL DEPARTMENT, DEPARTMENT OF AGRICULTURE FOR SCOTLAND.

Strawberry disease.—The field plot experiments are designed to test various treatments of soil which might check the disease, to find resistant varieties, and to discover how long the disease persists in the soil. Treatment with cresylic acid has given promising results.

Bracken disease.—At Garelochhead the occurrence of an endotrophic mycorrhiza in the smaller roots of healthy bracken was confirmed, but does not appear to have any relation to the incidence of the disease. The disease affects the fronds and the whole appearance suggests an infection of the aerial parts of the plant, carried by the wind or by insects. One fungus which developed in the majority of the cultures appears to be identical with that described by Miss Barnett (1931) as an imperfect stage of *Mycosphaerella.*

Disease of a different character was found on Ben More estate in Argyllshire, where it is limited to damp areas and the vicinity of trees. In this case the lower surface of the leaves is covered with a conspicuous external growth of white felt-like mycelium. The fungus has been identified and named *Corticium anceps* (*Bres. et Syd.*) Gregor.

It is concluded that two distinct bracken diseases are present in Scotland, each capable, under suitable conditions, of destroying the aerial portions of the plant. Infection experiments are to be continued.

21. SEED TESTING AND PLANT DISEASE DIVISION, MINISTRY OF AGRICULTURE FOR NORTHERN IRELAND.

SEEDS.

Ultra-violet light tests in connection with purity of ryegrass species and strains.—Work on this problem is being continued with promising results. The filtered ultra-violet light test for ryegrass seedlings (described in last year's report) ordinarily distinguishes short-lived from long-lived types. Among the former class, which reacts positively to the test, are *Lolium multiflorum*, Lam., *L. multiflorum*, Lam., var. *Westerwoldieum*, *L. temulentum*, Linn., *L. remotum*, Schrank., *L. Brazilianum*, Nees, certain inferior types of *L. perenne*, Linn. such as New Zealand South Island and Australian Wimmera. The non-reacting class is confined solely to certain valuable strains of *L. perenne*, Linn. including British indigenous, British commercial, New Zealand Hawke's Bay, Svalof Victoria, Jaederesk and Φtofke. Exceptions occur in this class to the extent that certain proportions of the seedlings give a positive reaction, about 10 per cent. in British commercial and about 2 per cent. in British indigenous, the other strains being intermediate in this respect. While these exceptions are very often due to Italian ryegrass seeds from which the awns have been lost, or to presence of seeds of hybrid origin, there remain some cases where the anomalous fluorescent individuals give rise to plants indistinguishable from perennial in general growth form and awn condition. On the other hand the fact that indigenous strains show lower proportions of these exceptions than commercial lots, suggests the possibility of genetical linkage between the reaction and some characters (physiological or morphological) responsible for persistency. This important aspect of the question involves genetical investigation, which is being actively pursued. Preliminary results to date indicate that the fluorescence character is inherited in a Mendelian fashion and behaves as a dominant in the F 1 and, judged by a limited number of back crosses, in the F 2 generations (1).

It has been found possible to utilise the ultra-violet light test for the identification of strains of New Zealand ryegrass. This is of importance, because in agronomic value New Zealand ryegrass strains are very variable, and, apart from lengthy growth tests, there has hitherto been no means of distinguishing the inferior from the valuable strains. The data obtained show a striking parallelism with the results of growth tests carried out independently by New Zealand workers (2).

Indigenous strains of grasses and clovers.—Remarkably good results have been obtained by the use of indigenous strains in two farm scale trials. In one case land was sown out under oats in 1929, but in view of heavy creeping thistle infestation an area of an acre was treated with sodium chlorate in February, 1930, and all herbage was destroyed. After a two months' interval the area was resown with a mixture including indigenous strains of ryegrass, cocksfoot and timothy. This area has looked better and has been much more heavily grazed by stock during the whole of 1931, than the remainder of the field. This was not a controlled experiment and quantitative analyses were not made.

In the second case two plots, each about two acres in a poor pasture, were ploughed out in 1930 and at once resown, one with an oat nurse, the other without any cover crop. The mixture used was, in lbs. per acre :—

Wild perennial ryegrass	12½	
Wild Cocksfoot	10	
Wild Red Clover	1½	
Wild White Clover	1	
Montgomery Red Clover	1½	
American Timothy	7	
Rough Stalked Poa	1	
	——	34½

Both plots have given excellent results in a very short time. Analyses of cut herbage in late summer, 1931, showed about 40 per cent. (dry weight) perennial ryegrass, 11 per cent. cocksfoot, 3½ per cent. timothy, 30 to 40 per cent. red clover and 3½ per cent. white clover. The higher red clover proportion was from the sowing without nurse, the lower from the oat plot. Later in the autumn further analyses showed a levelling up of the red clover percentages. In the year in question the presence or absence of nurse crop apparently had no effect unless in causing the transitory difference in red clover herbage.

Wild White Clover trials.—Trials on farm scale for the comparison of commercial stocks of English, Irish and New Zealand wild white clovers have been completed and a report published (3). The clovers were judged upon sward formation when sown in mixture at 2–3 and 4 years old. The centres chosen were distributed over the whole of Northern Ireland. Kent and County Down strains gave materially better results in practically every case than New Zealand. On the average there was little to choose between English and Irish. Average marks awarded out of a maximum of ten were Kent 6·9, County Down 6·2, New Zealand 2·8. Most of the New Zealand stocks showed a distinct tendency to Dutch type.

WEEDS.

Creeping thistle.—Cutting trials conducted on badly infested land in County Down showed that two cuttings, if the first was early, reduced the following year's thistle crop by more than 90 per cent., at a cost of about thirty shillings per acre, the " value " of the thistles before and after treatment being assessed by counting the number of plants per one two-hundredth acre and multiplying that number by the average height in inches of the thistles in mid-June. Three cuttings in 1929 showed no improvement over two cuttings if the first of the two was made early in June. These results, together with those reported last year upon the use of sodium chlorate against creeping thistle in arable land, have been published (4).

PLANT PATHOLOGY.

Potato diseases.

Ordinary or Late Blight (*Phytophthora infestans* de Bary).—The series of experiments carried out to determine the relative merits of spraying and dusting for controlling Late Blight under conditions obtaining in Northern Ireland has been concluded and the results published (5). At present, dusting cannot be recommended in preference to spraying with a standard mixture.

Experiments carried out with a view to determining the varying degrees of susceptibility of haulms and tubers of more recently introduced potato varieties to Late Blight are in progress.

Pink Rot (*Phytophthora erythroseptica*—Pethy. and Murphy).—Further advance has been made with regard to the study of this disease in the laboratory and in the field. Results obtained in previous seasons have been confirmed. The question as to whether Pink Rot may be ranked as a storage disease apart from its occurrence in the crop at the time of lifting is being investigated. Methods of infection in the field, varietal susceptibility, and measures for the prevention and control of the disease are being investigated on a farm where regular epidemics of the disease occur.

Flax diseases.

The value of organic mercurials for controlling seed borne diseases of flax (*Colletotrichum Lini* (Westerd.) Toch. and *Polyspora Lini* Lafferty) is under test.

Oat diseases.

The question as to the most satisfactory seed treatment for securing the control of loose smut (*Ustilago avenae* (Pers.) Jens.), closed smut (*Ustilago Kolleri*, Wille), leaf spot (*Helminthosporium avenae* (Bri. and Cav.) Eid.) and seedling diseases of the oat in general has been receiving attention for three seasons. A comprehensive series of field experiments has been carried out each year at the Agricultural Research Institute for Northern Ireland, Hillsboro, Co. Down, and the results obtained from these experiments have been prepared for publication. A brief and popular account of the work has already been published (6). Organic mercurials (" Ceresan " and " Abavit B ") have given the best results as general seed disinfectants. Formaldehyde has proved very satisfactory for smut control but has not controlled other seedling diseases. Copper compounds exerted some control but cannot be recommended on account of the liability of germination injury following their use. Sulphur and gypsum were of no value.

In collaboration with the County Instructors in Agriculture a number of field trials is being carried out in order to test the general value of the results in Northern Ireland. Work dealing with further aspects of this problem is in progress.

Fruit diseases.

American Gooseberry Mildew (*Sphaerotheca mors-uvae* (Schw.) Berk).—Work in connection with the control of this disease has been concluded for the time being and the results obtained up to date have been published (7).

Apple Scab (*Venturia inaequalis* Aderh.)—Summer spraying for the control of Apple Scab was carried out generally during 1931 and this operation has now become adopted by orchardmen as a routine measure. The season was as treacherous as any since 1923 and very thorough spraying with accurate timing of the applications was needed in order to keep the disease under control. Growers possessing power-driven spraying machines and consequently able to speed up the operation managed to spray up to six times during the season. The importance of early spraying was clearly shown, and growers who commenced operations late did not succeed in obtaining satisfactory control of the disease.

The manurial experiments commenced in a County Antrim orchard in 1929 were continued during the season. Unfavourable weather conditions and the very short crop produced precluded the recording of such interesting results as those obtained in 1930, but it is hoped to carry on with the work in 1932. The results obtained are being investigated in collaboration with the Department of Botany, Imperial College of Science and Technology, London University, and the Department of Agricultural Chemistry, The Queen's University, Belfast.

Leather Rot of Strawberries (*Phytophthora spp.*).—This disease of strawberry fruits was recorded for the first time in Northern Ireland in 1931. A number of cases has been investigated and it is suspected that more than one species of *Phytophthora* may be responsible. The diagnosis of the isolations which have been made is receiving attention.

Winter spraying.—Results obtained from comparative tests carried out with various tar distillate washes have been published (8).

Forest tree diseases.

A complete account of the work carried out up to the end of 1929 in connection with the control of diseases and weeds in the forest nursery has been published (9). Experiments relating to the comparison of the use of sulphuric acid and aluminium sulphate are still in progress.

MYCOLOGY.

Since 1923 a carefully compiled record has been kept of fungi (parasitic and saprophytic) which have been noted as new to Ireland or Northern Ireland. An annotated list of these new records has been published (10). This list adds 311 species and varieties to the known fungus flora of Ulster, as it stood at the end of 1922.

Titles of papers issued during the year.

1. Mercer, S. P., and Linehan, P. A.: Experiments in diagnosis of species and varieties of *Lolium* by the Gentner screened ultra-violet light method. *Sixth Internat. Seed Testing Cong.*, Wageningen, Holland, 1931. Statsfrøkontrolstation, 15 Fjords Allée, Copenhagen V.
2. Linehan, P. A., and Mercer, S. P.: A method of distinguishing certain strains of New Zealand perennial ryegrass (*Lolium perenne*, L.) by examination of seedlings under screened ultra-violet light. *Sci. Proc. Roy. Dublin Soc.* **20,** 1931.
3. Mercer, S. P., and Clouston, D.: Wild white clover varieties. *J. Min. Agric. N. Ireland.* **3,** 152, 1931.

4. Mercer, S. P.: Creeping thistles. *Ibid.*, **3**, 143, 1931.
5. Muskett, A. E., and Cairns, H.: The control of ordinary or late blight of the potato in Northern Ireland. I. Spraying versus dusting—further experiments. *Ibid.*, **3**, 117, 1931.
6. ——— ———: The disinfection of seed oats. *Farmers' J.* (*Ulster Farmers' Union*). Feb., 1931.
7. Muskett, A. E., and Turner, E.: The control of American gooseberry mildew in N. Ireland. II. *J. Min. Agric., N. Ireland.* **3**, 83, 1930.
8. ——— ———: Tar distillate washes and the winter spraying of apple trees. *Ibid.*, **2**, 97, 1930.
9. Muskett, A. E.: The control of diseases and weeds in a forest nursery. *Ibid.*, **3**, 102, 1931.
10. Muskett, A. E., Carrothers, E. N., and Cairns, H.: Contributions to the fungus flora of Ulster. *Proc. Royal Irish Acad.* **49**, Sec. B. 2, 1931.

E.

AGRICULTURAL PARASITOLOGY.

22. INSTITUTE OF AGRICULTURAL PARASITOLOGY, LONDON SCHOOL OF HYGIENE AND TROPICAL MEDICINE.

The research work of the Institute has continued, during the past year, along four distinct lines, viz. :—(a) eelworm infestations affecting plants of economic importance and allied free-living eelworms in the soil ; (b) helminth infestations of insect pests, particularly as regards the rôle they play in biological control of such pests ; (c) the differential diagnosis and bionomics of helminth parasites of stock and other mammals and birds of economic importance ; and (d) studies in chemotherapy in relation to helminth control.

(*a*) *Eelworm infestations of plants.*—Dr. M. J. Triffitt, who has for several years made a special study of the eelworm *Heterodera schachtii*, has recently published observations (1) on this nematode parasitising potatoes, showing that the life cycle of the parasite on this host in Britain differs in several important respects from that of the beet-infecting strain in Germany, and that these differences are of some significance from the practical standpoint of controlling the disease. A further paper by her (5) describes the cellular changes which take place in the tissues of infected plants in response to the parasite and discusses the pathological significance of these changes as demonstrated by experiments both in pot-culture and in the open field. Secondary invasions of fungus parasites are noted, and the extension of fungal hyphae into the normal host tissues following primary damage by the nematode is described. The identification of the fungus involved is given in a subsequent note (9).

Following reports received in correspondence from several agricultural advisers, field observations were carried out on a number of infections of *H. schachtii* on peas. These observations have been published (14), but the research is being continued.

Dr. T. Goodey has continued his researches on the plant parasitic nematodes other than those of the genus *Heterodera*. In a paper published in 1930 (2) the morphology and life-cycle of *Tylenchus agrostis* (Steinbuch 1799) are, for the first time, fully described, together with the effects of the nematode on the host plant. A detailed comparison is made between this nematode and *T. tritici*, a better known form with which it has been identified, and the conclusion is drawn that *T. agrostis* is a valid species. The symptoms caused by *Aphelenchus ritzemabosi* in a host which, when grown in the open, has not hitherto been found to be attacked, have been recorded (6). The increasing incidence of this serious greenhouse pest in plants grown in the open is noted, and suggestions are made regarding its possible mode of dissemination.

(*b*) *Helminth infestations of insect pests.*—Dr. J. N. Oldham has recorded (4) the occurrence of a parasitic nematode *Parasitylenchus scolyti* n. sp., in about 60 per cent. of elm bark-beetles obtained from one source, of which 38 to 39 per cent. showed evidence of sterility having been produced as a direct result of the infestation. The parasite is described and named, and its significance as a factor limiting the spread of the hosts, which are known to be carriers of the causative organism of elm disease, discussed.

Additions to the information contained in a previous paper on *Tylenchinema oscinellae* Goodey, 1930, have been made by Dr. Goodey (13). These are concerned chiefly with the occurrence of the parasite in the overwintering generation of the frit-fly, but further points relating to the behaviour of the worm within the host and the mutual effects of the parasitism on both host and nematode are discussed, together with some interesting facts regarding the geographical distribution and systematic relationships of the parasite.

A complete list, with bibliography, of the arthropod intermediate hosts of *Hymenolepis diminuta* as recorded up to date has been compiled and published by Dr. J. N. Oldham (7). The successful infection of larvae of *Ceratophyllus wickhami*, the squirrel-flea, with this rat cestode is also described (7).

(*c*) *Helminth parasites of mammals and birds.*—Dr. D. O. Morgan has published an account (3) of the differential diagnosis of the larvae of some helminth parasites of sheep and goats, showing that the larvae arising from various eggs which cannot be differentiated show certain points of diagnostic importance. He has also put on record (8) the presence of a new nematode infection in the liver of the wild rabbit due to *Hepaticola hepatica*, normally associated with disease in rats. His previous studies upon the gapeworm problem have been maintained and he has recorded the occurrence of gapeworms in nestling starlings and adult fowls (11).

Dr. J. N. Oldham has produced (10) a valuable list of the known parasites of common rats and this has been reprinted for distribution by the Imperial Bureau of Agricultural Parasitology.

Some preparatory work in a detailed investigation on ascariasis in pigs (12) has given valuable information regarding the duration of ascaris infestations and has shown that heavily infected pigs acquire no immunity against later infection. Ample provision has now been made for these studies during the coming year.

Titles of papers issued during the year.

1. Triffitt, M. J.: Observations on the life-cycle of *Heterodera schachtii*. *J. Helminth.* **8**, 4, 1930.
2. Goodey, T.: On *Tylenchus agrostis* (Steinbuch, 1799). *Ibid.*, **8**, 4, 1930.
3. Morgan, D. O.: On the differential diagnosis of the larvae of some helminth parasites of sheep and goats. *Ibid.*, **8**, 4, 1930.
4. Oldham, J. N.: On the infestation of elm bark-beetles (Scolytidæ) by a nematode, *Parasitylenchus scolyti* n.sp. *Ibid*, **8.**, 4, 1930.

5. Triffitt, M. J.: On the pathogenicity of *Heterodera schachtii* to potatoes and mangolds. *Ibid.*, **9**, 1, 1931.
6. Goodey, T.: Leaf-blotch in *Verbena venosa* caused by *Aphelenchus ritzemabosi*. *Ibid.*, **9**, 1, 1931.
7. Oldham, J. N.: On the arthropod intermediate hosts of *Hymenolepis diminuta* (Rudolphi, 1819). *Ibid.*, **9**, 1, 1931.
8. Morgan, D. O.: On the occurrence of *Hepaticola hepatica* as a natural infection of the wild rabbit in England. *Ibid.*, **9**, 1, 1931.
9. Triffitt, M. J.: Note on a fungus parasite associated with *Heterodera schachtii* infections on potatoes. *Ibid.*, **9**, 2, 1931.
10. Oldham, J. N.: The helminth parasites of common rats. Ibid., **9**, 2, 1931.
11. Morgan, D. O.: On the occurrence of gapeworms in nestling starlings and adult fowls. *Ibid.*, **9**, 3, 1931.
12. ————: Some observations on experimental ascariasis in pigs. *Ibid.*, **9**, 3, 1931.
13. Goodey, T.: Further observations on *Tylenchinema oscinellae* Goodey, 1930, a nematode parasite of the frit-fly. *Ibid.*, **9**, 3, 1931.
14. Triffitt, M. J.: On the eelworm *Heterodera schachtii* attacking peas in Britain. *Ibid.*, **9**, 3, 1931.

23. DEPARTMENT OF HELMINTHOLOGY, DEPARTMENT OF ZOOLOGY, UNIVERSITY OF EDINBURGH.

(a) The study of the bionomics of the lesser liver fluke of sheep was continued throughout the year and a preliminary account of its life-history has been published. It was found that the fluke was limited in its distribution to the west of Scotland, that the vector is a land snail—perhaps more than one species is involved—which becomes infected by swallowing the egg of the parasite while feeding on the droppings of the sheep. The outline of the development of the parasite in the snail has been studied and sheep have been infected experimentally by feeding on infected snails (2).

(b) The bionomics and the possible control of the commoner roundworms of sheep are being investigated. There is no remaining doubt that this is the most important condition affecting sheep generally in Scotland (with the possible exception of liver-fluke disease). No satisfactory method of control which is at once efficient and cheap has yet been found (1, 6).

(c) Thanks to the co-operation of the Fishery Board, the Royal Scottish Museum and other public bodies and private individuals, opportunities have arisen during the year for the examination of a variety of Scottish mammals, birds and fish, and records are being accumulated of their parasitic fauna. Particular attention is being paid to deer, squirrels, and other animals of economic importance, or which directly affect agriculture. Two new species of roundworms have been described from the red-deer and one from the grey squirrel. It is too early to make any definite statements about the relationship of the helminths of deer to those of stock animals ; but the results of the survey promise to be of considerable interest.

(d) Attempts are being made to co-operate with the Zoological Society of Scotland in the examination of the carcases of exotic animals for the presence of helminths (4). Although this examination has not been systematised, several new species of parasitic worms have been recovered from animals, such as the tiger (3), which are, parasitologically speaking, very intimately connected with both human and veterinary helminthology. It is hoped that this co-operation may become more complete and intimate so that, on the one hand, material for teaching and research not otherwise easily obtainable may become available, and on the other information as to the control of parasitic worms in captive wild animals may be rendered accessible.

(e) Owing to lack of professional assistance it was found impracticable to continue the field work on roundworms in pigs and the investigation has been transferred to the laboratory where *in vitro* experiments on the bionomics of the parasite are in progress.

Titles of papers issued during the year.

1. Cameron, T. W. M. : Parasitology and the practitioner. *Veter. Rec.* **7**, 2, 31.
2. ———— : Experimental infection of sheep with *Dicrocoelium dendriticum*. *J. Helminth.* **9**, 41.
3. ———— : On some lungworms of the Malay tiger. *Ibid.*, **9**, 147.
4. ———— : On a species of Trichostrongyle from the Tasmanian Devil. *Ibid.*, **9**, 153.
5. ———— : Helminth parasites of poultry. *Veter. J.* **87**, 7.
6. ———— : Goat sickness and parasitic worms. *Brit. Goat Soc. Yr. Bk.*

F

ANIMAL PATHOLOGY.

24. RESEARCH INSTITUTE IN ANIMAL PATHOLOGY, ROYAL VETERINARY COLLEGE.

Mastitis in bovine animals.

Bacteriology.—(i) A more intensive study of mastitis streptococci, which has been carried on during the past year, shewed that a number of strains possessed characters which were strikingly different from those of ordinary mastitis streptococci. For instance, they were strongly haemolytic at the time of isolation and highly virulent for small experimental animals. The main interest and importance of this observation however lay in the discovery that the strains in question were quite indistinguishable from certain streptococcus strains of human origin. A large series of the latter were examined for comparison, most of which had been isolated from the throat and were from actual cases of disease in human beings. The evidence strongly suggested therefore that the mastitis streptococci in question were of human origin and that they had been implanted in the udder during the course of milking. The fact that enquiry in these instances failed to elicit any definite history of coincident disease among the milkers or other persons in contact does not rule out this probable explanation. Out of 82 cases of clinically obvious streptococcus mastitis examined at random, bacteria of this nature were encountered in 13 cases, indicating that infection of the udder with streptococci from man is more frequent than has been hitherto supposed. These 13 cases occurred in widely separated parts of the country, and in cows which had been hand-milked. Reports of this work have now been published in detail (6, 7, 8, 9, 10).

(ii) When samples of udder milk are examined bacteriologically, a number of different kinds of streptococci can be isolated and for more than one reason it is essential to know whether given strains are to be regarded as potential incitants of disease or as harmless inhabitants of the udder. Information on this subject is now being acquired systematically by examining at intervals milk samples from a number of individual cows and making a record of the varieties of streptococci present, together with any abnormalities in the milk and the history of the animals.

Diagnosis.—In attempting to diagnose those cases of mastitis that are not readily detectable by clinical means, methods involving cultivation of the causal organism hold first place. Such methods however may prove to be rather cumbersome when they are used on a large scale. In consequence, efforts towards simplifying the technique have been continued during the year. For this purpose a new culture medium has been developed and this is now being put to practical test in the Institute with a considerable measure of success.

Prevalence of streptococcus mastitis.—Since the beginning of this work in 1928 a good deal of information has been accumulated regarding the prevalence of streptococcus mastitis in this country. Up to the present, milk samples from some 1,285 cows belonging to 23 herds have been examined, and 503 cows (39·1 per cent.) have been found to show definite infection, usually of a latent nature, in at least one quarter of the udder. The numbers of infected cows in these herds varied from 11 to 65 per cent. The average figure given is high but it can probably be taken as a fair estimate of the prevalence of the most common form of bovine mastitis. At the same time it ought to be mentioned that there is no reason to suppose that the disease is more widespread in Great Britain than in other countries where dairying is carried on intensively. Unfortunately, mastitis is by no means confined to herds where the standard of cleanliness is low, in fact the incidence is sometimes above the average in herds where the conditions for clean milk production are beyond reproach.

Control.—The control measures relating to chronic streptococcus mastitis have been continued in accordance with the scheme outlined in the report for 1929–30. About 400 cows belonging to six herds are now under observation, and it may again be said that the results are encouraging. In one herd, originally numbering about 70 milch cows, and from which 8 found to be infected at the first tests were promptly eliminated, the chronic form of streptococcus mastitis has not been observed for the past 18 months. This herd, which has been recruited with purchased first-calving heifers, now numbers about 90 milch cows.

In three other herds, which are under control and in which a number of the originally infected cows still remain, only a small minority of previously healthy cows have had to be transferred to the infected group. Time alone can show to what extent eradication measures on these lines will be successful.

Lectures and reviews.—In response to requests from various quarters, the present state of scientific knowledge of bovine mastitis has been reviewed (1), addresses on the subject have been given before veterinary societies (3, 4) and popular communications dealing more particularly with the control of the disease have been published (2, 5).

JOHNE'S DISEASE.

Research work on this disease has been continued. A large number of johnin tests have been made in infected herds in the course of attempts at eradication. This has afforded an opportunity for gaining experience of the test, and the information has been supplemented in some 30 cases by post-mortem examination of reactors. This further information has supported in the main the diagnostic value of the test. The establishment of a reliable technique for the isolation of the causal organism from animals in the early stages of the disease is being investigated.

AVIAN TUBERCULOSIS IN CATTLE.

Tubercular infection in cattle originating from poultry has been reported in the United States and in Denmark, but has attracted scanty attention in this country. In the course of investigations on John's disease, tuberculosis in cattle of avian origin was shown to exist on three farms, as a result of certain animals having reacted to johnin. It has been possible to verify the nature of the infection in six cases, viz., in four calves and in two adult animals. On two of the three farms it was subsequently ascertained that tuberculosis was widespread among the poultry.

Titles of papers issued during the year.

1. MINETT, F. C.: Bovine mastitis. A short review of present knowledge. *J. Dairy Research.* **2,** 84, 1931.
2. ——————: Bovine mastitis. *J. Brit. Dairy Farmers' Assoc.* **43,** 27, 1931.
3. STABLEFORTH, A. W.: Epizootiology of bovine mastitis of streptococcic origin. *Veter. Rec.* **11,** 393, 1931.
4. MINETT, F. C.: Bovine mastitis. *Ibid.,* **11,** 595, 1931.
5. ——————: Bovine mastitis. *Official Hdbk. Central Council of Milk Rec. Soc,* 62, 1931.
6. ——————: Milk-borne streptococcus epidemics. *Proc. Roy. Soc. Med.* **24,** 1706, 1931.
7. STABLEFORTH, A. W.: Milk-borne streptococcus epidemics. *Ibid* **24,** 1709, 1931.
8. MINETT, F. C., and STABLEFORTH, A. W.: Studies on bovine mastitis. IV. The occurrence in mastitis of hæmolytic streptococci showing group similarity to *Streptococcus pyogenes* of man. *J. Comp. Path. & Therap.* **44,** 114,1931.
9. MINETT, F. C., STABLEFORTH, A. W., and EDWARDS, S. J.: The biology of *Streptococcus agalactiae. Zbl. Bakt.* Orig. Abt. 1. **122,** 466, 1931.
10. MINETT, F. C.: The importance of studying the diseases of the cow's mammary gland. Communicated to the Section of Agric., Brit. Assoc. *Veter. Rec.* **11,** 1164, 1931.
11. ——————: Milk as a pathogenic agent. *Communicated to Second Internat. Cong. of Comp. Path.,* Paris, 1931.

25. INSTITUTE OF ANIMAL PATHOLOGY, CAMBRIDGE UNIVERSITY.

FILTERABLE VIRUSES.

Epithelioma contagiosum.—The virus of pigeon pox has been cultivated *in vitro* in a medium consisting of blood plasma and embryo chick tissues. It was found that an increase in the virus content could only be demonstrated when the chick tissue contained epithelial cells and that preparations containing heart or liver were unsatisfactory. The source of the virus appeared to be of some importance since cultures prepared from the blood serum or liver of affected birds as well as filtrates from cutaneous lesions invariably failed.

Successful results were obtained however with bacteria-free emulsions prepared from infected follicles (1).

Further investigations have been made into the *in vitro* cultivations of the virus with a view to simplifying the technique. So far however it has not been found possible to improve on the plasma clot type of medium.

Venereal disease of sheep.—Venereal disease is a transmissible condition characterised by pustulo-ulcerative lesions on the vulva of the ewe and on the penis and sheath of the ram. The application of desiccated scabs to scarified areas on the thighs of lambs gives rise to a vesico-pustular eruption which closely resembles that of contagious pustular dermatitis. It can be differentiated from the latter disease however by cross immunity experiments. The causal agent would appear to be a filterable virus (2).

BACTERIOLOGY.

Salmonella infection in calves.—The study of cases of scour in calves associated with this type of infection has been continued. The disease, which is indistinguishable clinically from other acute forms of calf diarrhœa, is very fatal to animals during the first few weeks of life.

Salmonella infection in the dog and cat.—Outbreaks of abortion in bitches and of enteritis in puppies and kittens, which appear to be due to infection with organisms of this group, are being investigated.

Bacillary abortion of ewes.—Further evidence has been obtained regarding the distribution of this disease and it has been suggested that the causal organism (*B. abortus ovis*) is sometimes responsible for a considerable mortality amongst infected ewes (2).

Pyobacillosis of British sheep.—It has been pointed out in a previous publication that caseous lymphadenitis of sheep due to the Preisz-Nocard bacillus is probably unknown in this country (3). Similar conditions exist however and an examination is being made of purulent lesions affecting the lymphatic glands and other organs of British sheep in order to ascertain the nature of the causal organisms (2).

Sterility in the mare.—An investigation is being carried out into the bacterial flora of the uterus of mares that are temporarily or permanently barren. Advantage is being taken of the opportunity to study the pathological changes present in the genital organs of animals that are cast on account of their being permanently sterile.

Classification of organisms of the B. welchii group.—A comparative study of the biological properties of numerous strains of the *B. welchii* group of organisms obtained from several sources has been completed. Four distinct types have been differentiated by toxin-antitoxin methods and characteristic differences in the antigenic structure of the toxins have been established (4).

HISTOLOGY.

Hypervitaminosis D.—The investigation into the histo-pathology of hypervitaminosis D with special reference to the influence of Ca/P intake has been completed. The pathogenesis of the condition was found to be in direct contrast with that of " rickets," and the study was concluded by a suggested explanation, based upon these findings, of the mode of action of the vitamin in the animal body (5).

Vitamin A deficiency.—The development of the lesions associated with avitaminosis A has been studied, with special reference to the supposed anti-infective properties of this vitamin. It would seem that this property is due to the fact that infective organisms are enabled to enter the body as a result of the keratinisation which is characteristic of a deficiency of the vitamin.

Vitamin C deficiency.—Attempts to produce scurvy in the dog have failed. Puppies fed on a diet entirely deficient in vitamin C for 150 days showed no ill effects.

Further experiments were carried out with a view to establishing the value of the " Hojer tooth method " in determining the vitamin C content of foodstuffs.

" Rickets " or " cripples " in lambs.—A study has been made of material from cases of so-called " rickets " or " cripples " of lambs in the north of England. There appeared to be no evidence of a scientific nature which could justify the classification of this disease as " rickets."

Nephritis in the dog.—A systematic study of organic kidney disease in the dog has been pursued and an attempt has been made to correlate the different types of structural alteration and the conditions under which they occur with the functional disabilities and clinical symptoms, as well as to classify these according to accepted methods. The existence of two types of contracted kidney has been established, namely, arterio-sclerotic nephritis, or primary ischaemic nephritis of Russell produced by arterio-sclerotic changes in the renal vessels, and a contracted kidney which results from a protracted glomerular or tubular nephritis.

Neoplasms in animals.—Various neoplasms of the lower animals have been examined with a view to ascertaining whether the same conditions determine the behaviour of certain types of neoplasm in these animals as in man.

A study of the blood of cattle and sheep in health and disease.—This investigation has been concluded. The blood of cattle and sheep has been examined at various ages from within a few hours of birth to the adult state. The appearances of the elements in supra-vitally stained and fixed specimens have been described and discussed and the actual numbers in which they presented themselves, and the proportions in which they appeared, recorded (6).

IMMUNITY.

Epithelioma contagiosum.—A series of experiments has been conducted to determine the value of several methods of vaccination against fowl pox and pigeon pox. It has been found that while vaccines consisting of living unattenuated virus are unsatisfactory, principally on account of the danger of setting up the disease involved in their use in healthy flocks, those in which the virus has been modified biologically are safe and potent. The vaccine of de Blieck has been compared with pigeon virus : both appear to be capable of inducing a solid immunity and, when applied under suitable conditions, are without danger. The antigenic value of vaccines consisting of chemically modified virus has also been investigated : that treated with phenol has given the best results, but the immunity which it produced was found to be of relatively short duration.

Vaccination of calves with B.C.G.—This investigation has been continued with the following results. (i) The strain of B.C.G. used throughout the experiments would appear to be avirulent for the calf and incapable of producing progressive tuberculosis even when administered intravenously in large doses. (ii) Whether given by the mouth or intratracheally, or by subcutaneous or intravenous injection, B.C.G. raises the resistance of a calf to a virulent experimental infection. (iii) An increase of resistance is less certain after feeding with B.C.G. than after intravenous injection, though feeding with the vaccine may in some instances induce as high a resistance as injection into the tissues. (iv) Intravenous injection has proved the most satisfactory method of vaccination. (v) The degree of increased resistance conferred upon calves by intravenous vaccination varies within wide limits, and appears in general to be directly proportionate to the dose of B.C.G. vaccine (7). Subsequent experiments have shown that intravenous vaccination of calves with B.C.G. produces a solid immunity to a test dose of virulent tubercle bacilli administered by the mouth some weeks later.

Bacillary abortion of ewes.—An investigation has been made of the endo-toxins of certain organisms of the paratyphoid group with special reference to *B. abortus ovis*, with a view to the preparation of a more satisfactory antigen for immunisation against bacillary abortion of ewes.

BIOCHEMISTRY.

Biochemical studies of the blood of sheep.—These studies formed part of an investigation into the etiology of the toxaemias of pregnancy and the pre-parturient and post-parturient forms of eclampsia of these animals. In an endeavour to reproduce artificially the symptoms of these conditions by inducing alterations in the mineral balance of the blood similar to those observed in natural cases, a critical survey has been made of the action of various gland extracts and chemical substances in this respect. It has been found that in the case of sheep it is exceedingly difficult to alter the mineral balance, and that the common agents employed to produce these changes in rats, rabbits and other animals have little effect in sheep.

The effects of feeding mineral supplements on the chemical content of the blood of sheep.—Experiments carried out on hill farms in Northumberland on which the sheep are found to have a low blood calcium content show that mineral supplements fed to ewes during the last half of the period of gestation can raise the blood calcium content to the normal level. It was found also that the calcium content of the blood of lambs born of such ewes was considerably higher than that of lambs from untreated ewes.

The effects of nematode worms on the metabolism of sheep.—Further experiments have confirmed the earlier results referred to in previous reports, and it has been established that while heavy infestations with these parasites may affect in some measure the absorption of fat and carbohydrate, that of protein is reduced by as much as 30–40 per cent. An attempt has been made to ascertain the mechanism of this interference with the absorption of protein.

Cellulose digestion in ruminants.—This investigation has been continued and a considerable amount of information has been obtained, especially in regard to the physiology of cellulose digestion in ruminants. The cellulose digesting organism referred to in previous reports has been employed to test the digestibility of the fibres of various foodstuffs and to determine the degree of lignification of rye grass at various stages of growth.

TOXICOLOGY.

An investigation is being made of variations in the alkaloidal content of certain plants which are poisonous to farm animals in relation to the strain, stage of growth, and nature of the soil. A comprehensive study has been made of the pharmacological and toxicological actions of taxine and of the alkaloids obtained from *Conium maculatum* and *Colchicum autumnale.* Visits have been made to farms in Cambridgeshire, Lincolnshire, Suffolk, Essex and Gloucestershire in order to obtain information regarding the species of plants most commonly responsible for cases of poisoning amongst livestock in those areas. A garden of poisonous plants has been established for the purpose of providing material for future research, and also a collection of specimen plants for demonstration purposes. A collection is being built up of dried specimens of all the poisonous plants in various stages of growth.

PARASITOLOGY.

Helminthology.—An examination has been made of the environmental condition of various nematode worms with a view to establishing methods of treatment based upon the information so gained. Some progress has been made in devising a method of cultivating the parasitic larval stages and the adult worms in a medium of known composition and similar to the normal environment of the parasites.

A number of worms and external parasites of domesticated animals as well as a collection of worms of marine fish has been examined and identified.

Comparison has been made of different methods of counting worm eggs and of the flotation fluids which may be used, and an attempt has been made to correlate the figures obtained from egg counts with the number of worms present, in an endeavour to compute the egg output of different parasitic worms.

Further experiments have been conducted to ascertain the anthelmintic action of various substances upon parasitic worms of the digestive tract of sheep and pigs.

Protozoology.—A preliminary investigation of blackhead disease of turkeys has been made during the 1931 season. Material from lesions in affected livers has been grown in tissue cultures—both alone and with embryonic hen-chick liver. Similar work has been carried out with coccidia from turkeys and hens.

DIAGNOSIS.

Tuberculin.—An investigation has been carried out of the preparation of various " tuberculins " with a view to securing a product which will give a smaller non-specific reaction in the double intradermal test than is at present the case with concentrated " old " tuberculin.

Titles of papers issued during the year.

1. GLOVER, R. E.: Experiments on the virus of *Epithelioma contagiosum*. 1*st Rep. of the Director, Inst. Animal Path. Camb.* 1, 1929-30.
2. BOSWORTH, T. J., and GLOVER, R. E.: Some observations on the nature of certain diseases of sheep. *Proc.* 49*th Ann. Cong. N.V.M.A., Norwich,* 1931.
3. BUXTON, J. B.: Experimental studies on the pathogenicity of the *Preisz-Nocard* bacillus for British sheep. 1*st Rep. Director, Inst. Animal Path. Camb.,* 39, 1929-30.
4. WILSDON, A. J.: Some observations on the classification of *B. welchii.* (In the press.)
5. INNES, J. R. M.: The pathology of hypervitaminosis D. 1*st Rep. Director, Inst. Animal Path. Cam.,* 93, 1929-30.
6. FRASER, A. C.: A study of the blood of cattle and sheep in health and disease. *Ibid.,* 114, 1929-30.
7. BUXTON, J. B., and GRIFFITH, A. S.: The use of B.C.G. in the vaccination of calves against tuberculosis. Interim Rept., 1931, *Lancet,* 393, Feb. 21st.

26. VETERINARY LABORATORY, MINISTRY OF AGRICULTURE AND FISHERIES.

FOOT-AND-MOUTH DISEASE EXPERIMENTAL STATION, PIRBRIGHT.

(*Under the general direction of the Foot-and-Mouth Disease Research Committee.*)

During 1931 an account of the work of the previous two years was published (1). The following is a brief summary of the more important points contained in the report :—

With respect to the influence of hydrogen-ion concentration, the virus survives long in suitable fluids of PH 7·2 to 8·0, with an optimum PH of 7·4.

The survival of dried virus may be greatly influenced by the nature of the substratum on which it is dried ; leather, hide and rubber are substrata favourable to the virus.

The virus, when dried on meat wrappings of stockinette and hessian, was found to survive as long as 45 and 46 days at 12° to 20° C., and 47 days at—2° to + 2° C.

In isolated organs from infected guinea pigs, kept at about 29° F., the duration of survival was found to vary from 82 days in the tongue to 145 days in the tendon.

In bovine carcases kept at 29° F. under conditions designed to follow as closely as possible those of the imported meat trade, the virus was found to survive in bone-marrow as long as 80 days.

Experiments on disinfection included many observations on the use of the commonest organic acids, which were found to be very effective. Sodium carbonate, in concentrations of not less than 4 per cent., was found to be a most effective disinfecting agent, and it is obviously suitable for employment in practice on a large scale.

Of 23 strains of virus derived from British outbreaks, 21 were found to belong to the " O " type. No "A" or " C " types were met with, and the remaining two strains were found to differ immunologically from all three of the recognised types, and from each other.

Of 10 strains received from Argentina, 3 were of the " O " type, and 6 were quite atypical ; the remaining strain could not be adapted to the guinea pig, and its type was undetermined.

It was shown that the ordinary brown rat (*Rattus norvegicus*) may be infected naturally with the disease. A study was made of the disease in rats inoculated artificially, and the disease was transmitted to healthy rats by contact. White rats were infected less readily, and mice only with some difficulty. The hamster (*Cricetulus griseus*) proved to be susceptible to inoculation.

Experience at Pirbright suggests that less than 2 per cent. of British cattle and about 5 per cent. of British pigs are resistant to inoculation with ordinary strains of virus.

In infected bovines the virus may appear in the general circulation some hours before the temperature rises, but it is never found earlier than that, and it may first appear in the blood after the reaction is well established. It generally occurs in the blood during the stage of pyrexia, and may be present throughout that stage.

In the urine the virus appears only irregularly and usually only for brief periods ; it may appear early in the incubative period.

Contrary to the experience of workers in France, it was found that a bovine is rarely infective by contact during the period of incubation. Natural infectivity seems usually to appear only when vesicles are formed, and often only when the vesicles are rupturing.

Confirmation was obtained of the observations of Lebailly, and of Vallée and Carré, that infectivity usually disappears very rapidly ; all of the test animals failed to transmit the disease by contact after the fourth day from the rupture of the vesicles.

No evidence was obtained of the existence of " carriers."

" Humoral " immunity to a virus of the same type was found to persist in cattle, in the absence of reinfections, for at least 32 months. Where the animal was exposed to reinfections, although without visible reaction, it was shown to persist more than three years (not end-point).

Various drugs were tested, but none was found to exercise any noticeable curative or prophylactic action.

VETERINARY LABORATORY, WEYBRIDGE.

Babesiasis and Anaplasmosis.—The strains previously obtained from South America, North Africa and South Africa were maintained. New strains from South Africa and Brazil were also received and examined. A study was commenced of redwater strains from Devonshire and North Wales. During the year 7 pedigree cattle were immunised before their despatch to Brazil and British Guiana.

Contagious abortion of cattle.—During the year 21,877 doses of the living vaccine were prepared and issued, and 977 agglutination tests were carried out in connection with vaccination or attempts to eradicate the disease by isolation.

Work was continued on the following points :—

(*a*) the significance of low agglutinating titres to *Br. abortus* in bovine blood serum ;

(*b*) the virulence of strains of *Br. abortus* after prolonged cultivation in the laboratory ;

(*c*) the appearance of *Br. abortus* in the udder and milk as a sequel to the subcutaneous inoculation of living cultures ;

(*d*) the distribution of *Br. abortus* in the bodies of infected cows, and particularly of chronic " carriers " ; and

(*e*) the persistence of infection in calves born of infected mothers.

Tuberculosis.

B.C.G.—During the year 1,425 doses of B.C.G. vaccine were prepared and issued for field trials in selected herds. The evidence obtained from these field trials had not, up to the present time, permitted the formation of any definite opinion as to the value of the method.

Canine.—An outbreak of tuberculosis at a large establishment was investigated. There was some evidence to suggest that dog-to-dog transmission occurred, owing to the prevalence of pica. The type of *B. tuberculosis* concerned was identified as bovine. (To be published shortly.)

Avian.—A study has been made of the incidence of avian tuberculosis on certain large poultry farms. The intradermal tuberculin test has been applied to large numbers of poultry, and its reliability tested on a considerable scale by subsequent post-mortem examinations. Certain properties of the avian type of *B. tuberculosis* are under investigation.

Swine fever.—The publication of the work on this disease, to which reference was made in the last annual report, has been temporarily postponed in order to include the results of the further work (on the survival of the virus) now in progress.

Verminous gastritis in sheep.—Observations carried out on sheep kept from birth under controlled conditions of infection strongly suggest that a partial immunity to *Ostertagia* and *Nematodirus* is developed as a result of infection, and that early infection with these worms also gives some protection against *Haemonchus* and *Trichostrongylus.* It was observed that, among lambs grazing a pasture which carries a heavy mixed infection, some may harbour *Ostertagia* and *Trichostrongylus* in large numbers but carry few or no *Haemonchus*, while others are heavily infected with *Haemonchus* as well as with worms of the other two genera—evidence that there is a specific as well as a group immunity.

Visits to various farms where outbreaks of verminous gastritis had occurred revealed something more of the comparative prevalence and severity of the outbreaks among sheep penned on arable ground. A system of penning lambs on root or forage crops, which encourages the disease, was found to be more widely practised than had previously been thought, and some outbreaks were definitely traced to its employment. Other outbreaks were traced to the system of cropping known as the Wiltshire rotation, which provides for the sheep to run frequently over the same land and at too short intervals of time for safety.

Ascaris infection in pigs.—A series of experiments on the susceptibility of young pigs under various conditions to infection with *Ascaris lumbricoides* has been completed, but it has not been found possible, under the several conditions tried, consistently to bring about infection with this worm. In one experiment a difference was observed between the development of *Ascaris lumbricoides* of man and pig.

Syngamiasis.—Cross-infection experiments were carried out which demonstrated that the strain of *Syngamus trachea,* which had caused several deaths among goslings on a certain farm, was the same as that which occurs in chicks and turkeys. The rapid disappearance of the infection from goslings used in the experiments suggested that they develop an age immunity similar to that developed by chicks. Efforts to infect ducklings failed, both with the gosling strain and the chick strain.

This worm does not appear previously to have been associated with loss among goslings.

A paper (2) given before the Derbyshire Division of the N.V.M.A. deals with the diagnosis of worm diseases by faecal examination. The various methods which may be employed are briefly described and the interpretation of the results of the examination is discussed.

Worm infections of poultry.—Many examinations and identifications have been made. A paper (3) on the "Parasitic diseases of poultry," read before the Annual Congress of the N.V.M.A., deals with various aspects of the causation of disease by worms in poultry and with their control. It is considered unlikely that anthelmintic treatment will prove a satisfactory means of control, which must depend mainly upon a careful planning of the arrangement and management of poultry farms in accordance with our knowledge of the bionomics of parasitic worms and of the etiology of worm diseases.

Strongyle infection of horses.—A paper (6) was published giving an account of work carried out on a stage in the life cycle of *Strongylus equinus*, one of the "red worms" of the horse. What is regarded as the mature third stage larva (previously unknown) was recovered from the ileo-caecal lymphatic gland of the guinea-pig after the ingestion of the infective stage; also from the liver and from the wall of the first part of the colon. Attempts to find it in those positions in the horse were not successful, but it is probable that it occurs there. The route taken by the larva in reaching these situations and its rate of development is discussed; and a description is given of three different forms which were recovered from guinea-pigs during the course of the work.

The importance of worm parasites in assisting bacterial invasion from the bowel.—An attempt was made to ascertain whether worm parasites will facilitate the penetration of the intestinal mucosa by pathogenic bacteria. The larvae of *Ascaris lumbricoides* were used as the penetrating nematode larvae. In the first experiments guinea-pigs were used, and *B. anthracis* was employed as the pathogenic bacterium; in a second series *B. suipestifer* was used in rabbits. No evidence was obtained to support the suggestion that bacterial invasion is favoured by the presence of the larvae. This work has been published (7).

Fowl paralysis.—Outbreaks of the disease known as Fowl Paralysis have been numerous and widespread during the past year, and have caused heavy mortality. A considerable amount of work has been carried out to determine the etiology of the condition, but so far with no success. Material obtained from numerous outbreaks has been inoculated by all the usual routes into fowls of varying ages. None of the inoculated fowls has developed the disease, and no evidence has been found to support the contention that the causal agent of the common form of fowl paralysis is a virus.

This investigation is being continued on the small scale that the laboratory facilities permit.

Coccidiosis of adult fowls.—A study of the duodenal type of coccidium, which is frequently found in adult birds affected with fowl paralysis, is in progress.

Fowl pox.—Work has been continued on the vaccine (a selected strain of pigeon-pox virus) which gave such promising results during the previous year. During the past year more than 537,000 doses of the vaccine were issued for use in the field, and the results were reported in almost every instance to be very favourable. The few exceptions were investigated, and some improvements were made in the method of the preparation of the vaccine.

Arthritis in pheasants.—A disease of young pheasants, affecting particularly the joints, was found to be due to infection with *Staphylococcus pyogenes aureus.* The evidence suggested that infection occurred through small wounds, and there was some suspicion that these might be due to the presence on the ranging ground of a heavy growth of thistles (8).

Fowl plague.—The work on the viability of fowl-plague virus, mentioned in the report for 1929–30, was published (9). It was shown that at "chilling" temperature the virus may survive as long as 287 days in muscle and 303 days in bone-marrow; in feathers kept in the open, but protected from direct sunlight, it may persist for at least 18 days.

A study was made of an atypical strain of virus from Egypt (10). The disease set up by this strain appears after a very much longer incubation period than is noted following the inoculation of ordinary strains of fowl-plague virus, and the disease runs a slower course. Moreover, the virus is present in the blood only in low concentration (minimal infective amount of 0·001 cc. as opposed to 0·00001 cc., or even much less, in ordinary fowl plague). In other respects no differences were found, and immunologically the virus agrees with ordinary strains. Investigation of seven strains of fowl-plague virus failed to reveal any differentiation into immunological types (11). Observations made during the course of this work suggested that acquired immunity to fowl plague is of comparatively short duration.

Disease in ducklings.—Several outbreaks of disease in ducklings have been proved to be due to infection with members of the *Salmonella* group (to be published shortly).

Fowl typhoid.—During the year 3,220 doses of vaccine were prepared and used in the field—apparently with excellent results.

Rabies-like disease in Trinidad.—During the year specimens were received from Trinidad in connection with a disease that has caused a considerable mortality in cattle and equines. Some human fatalities are also attributed to the same disease. The disease is associated with the occurrence of bodies indistinguishable from the Negri bodies of rabies, and there are also (in inoculated rabbits) ganglionic changes similar to those seen in rabies. The presence of a virus was first demonstrated by Hurst. A strain of the virus has been established at Weybridge, and experiments are in progress.

Titles of papers issued during the year.

1. *Fourth progress report of the foot-and-mouth disease Research Committee.* Appendix I. H.M. Stationery Office, London, 1931.
2. Taylor, E. L.: The faeces in worm diseases: their value for diagnosis and their hygienic disposal on the farm. *Vet. Rec.*, June 13th, 1931.
3. ————: The parasitic diseases of poultry. Published as a separate paper by the N.V.M.A., Aug., 1931.
4. ————: Some significant points concerning the parasitic worms of fowls and the causation of worm diseases. *Vet. J.*, **87**, 1, 28, 1931.
5. ————: Gapes (*Syngamiasis*)—the relation of wild birds to the disease among chicks. *Lflt.* 69. *Min. Agric.*
6. ————: The third stage larva of *Strongylus equinus*. *Ann. Trop. Med. and Parasitol.*, **24**, 4, 1930.
7. Taylor, E. L., and Purchase, H. S.: Do penetrating nematode larvae assist bacterial invasion from the bowel? *Parasitol.*, **23**, July, 1931.
8. Hole, N., and Purchase, H. S.: Arthritis and periostitis in pheasants caused by *Staphylococcus pyogenes aureus*. *J. Comp. Path. and Thera.*, **44**, 4, 1931.
9. Purchase, H. S.: Experiments on the viability of the virus of fowl plague under trade conditions. *Vet. Rec.*, June 13th, 1931.
10. ————: An atypical fowl-plague virus from Egypt. *J. Comp. Path. and Thera.*, **44**, 1, 1931.
11. ————: A study of cross-immunity with viruses of fowl-plague and observations on the duration of immunity. *Brit. J. Exp. Path.*, **12**, 1931.
12. Hole, N.: The poultry industry: a new field for the general practitioner. *Vet. J.*, **87**, 2, 1931.

27. ANIMAL DISEASES RESEARCH ASSOCIATION, EDINBURGH.

Grass disease.—During the season 1931 collections of *Sminthurus viridis*, gathered from pastures upon which grass disease had occurred, were fed experimentally to horses with negative results.

Samples of blood obtained from acute and sub-acute cases of the disease were submitted for biochemical analysis at a field station set up in the affected area. Positive results were obtained in every acute case, and these were of such a nature that the acute cases could readily be distinguished from the sub-acute, and the control normal cases, by laboratory findings.

Louping-ill.—The results of the 1930 experiments in which it was found that louping-ill was due to a filterable virus have been fully confirmed, and it has been found that the disease may be transmitted to healthy sheep not only by injection of emulsions prepared from the central nervous system and of blood collected during certain phases of the febrile stage of the disease, but that emulsions of ticks (*Ixodes ricinus*) which had engorged upon cases of louping-ill were also infective.

Further, it has been found that ticks, which—as larvae—had engorged upon cases of louping-ill, were capable, after moulting to nymphae, of transmitting the disease both when emulsified and inoculated into mice and by infestation upon healthy sheep.

It has thus been proved that *Ixodes ricinus* represents a vector of the infective virus.

Based on the previous finding that the subcutaneous injection of dilutions of virus could elicit a solid immunity, attempts have been made to prepare a protective vaccine with living virus. It was found that, while a reliable immunity could be obtained by this means, the vaccine was unsafe. A number of controlled field experiments have been made in the autumn of 1931 with formolised virus. The results of these observations are encouraging, and an extended series of these experiments will be made during the spring of 1932.

It has been found that a tick-borne febrile disease, which can be readily differentiated from louping-ill on clinical, histological and immunological grounds, attacks sheep in the louping-ill areas. This disease may be further differentiated from louping-ill by its innocuity to mice but, while the infective agent does not appear to pass through the British Berkefeld filter, the etiology of the disease is yet unknown. This disease, which appears to be the cause of very considerable economic loss, has been provisionally named "tick-borne fever." Tick-borne fever appears to predispose sheep to other infections, but there is yet no evidence of the specificity of tick-borne fever infection as a pathogenic excitant of louping-ill virus.

An extensive study of the histopathology of louping-ill as it affects the sheep and the mouse has been made. In each animal the characteristic lesions are those of meningo-encephalo-myelitis.

Since the importance of the British tick, *Ixodes ricinus*, as a parasite of sheep and cattle has become clearly recognized, an extensive study of its ecology and general bionomics has been in progress during the last few years and is now nearing completion.

"Pine" in sheep and calves.—An acute condition of progressive debility, or "pine," occurs on extensive areas in the island of Tiree. A similar condition appears to be prevalent on large tracts of hill grazings in the Western Highlands and in other parts of Scotland. Field evidence suggested that the condition is associated with mineral deficiency. In conjunction with the Rowett Research Institute and the Macaulay Institute for Soil Research the problem is being investigated.

An experiment devised to determine both the possible curative and preventive effects of the administration of minerals as a supplement to the affected grazings was set up in Tiree at the commencement of the grazing season, 1931, when blood analysis was carried out on twenty-one stirks which were used as experimental animals. These were divided into three groups of seven: one group was fed crude iron oxide, the second received crude iron oxide plus dicalcium phosphate, the third group was reserved as a control. At the end of July a second series of blood analyses was carried out, and at that time it was found that the condition of the animals to which supplementary minerals had been fed was definitely superior to that of the controls. Severe cases of "pine" to which carbonate of iron was administered rapidly improved in condition. These observations will be further amplified by observing the effect of the administration of minerals upon animals on the affected grazings in 1932.

Scrapie.—Scrapie has been subjected to a biochemical and cytological investigation and, while definite deviations from the normal have been found, it is yet too early to interpret their significance.

A systematic enquiry upon the occurrence of the disease within the Scrapie areas is in progress.

Braxy.—Further studies of methods of immunisation against Braxy appear to show that vaccines prepared from formolised whole culture are definitely superior to those prepared from toxin-antitoxin mixture.

Estimation of normal standards.—Since very little data exist upon the normal biochemical and cytological standards of blood and body fluids of the domestic animals, a programme of work designed to furnish information upon these matters has been elaborated and is now being carried through.

Title of paper issued during the year.

1. Greig, J. R., Brownlee, A., Wilson, D. R. and Gordon, W. S.: *The nature of Louping-ill.* Moredun Institute, Animal Diseases Research Assoc., Edin.

28. ANIMAL DISEASES DIVISION, MINISTRY OF AGRICULTURE FOR NORTHERN IRELAND.

Abortion.—An opportunity for studying an outbreak of contagious bovine abortion in a large herd presented itself during the year. The herd has been submitted to the agglutination test at regular intervals and records kept of the dilution at which agglutination occurred and the subsequent date of abortion (if this took place).

Results would seem to indicate that agglutination in a 1/25 dilution is highly suspicious of infection and should be treated as being positive in any scheme of segregation using the blood test as a means of separating " clean " from infected animals.

Experiments to assess the value of live anti-abortion vaccine in commercial herds have met with many difficulties. Few farmers were found to be agreeable to having only a proportion of their animals vaccinated and these invariably elected to sell a number of the experimental animals, so that ultimately the final figures were too small to permit of any deductions being made. This work is being continued as occasion permits.

Sterility.—This condition appears to exist independently of contagious abortion. On farms where a large number of animals was affected, the agglutination test for contagious bovine abortion gave negative results.

Bacillary white diarrhoea.—A scheme is being controlled from the laboratory which has as its ultimate aim the eradication of bacillary white diarrhoea in Northern Ireland. The scheme, which has as its basis the blood test, has already met with considerable success.

The collection of blood samples and removal of reactors is under official control.

In connexion with a laying test, it was noted that hens which had passed the blood test gave a better egg production than reacting hens. A short note has been published on this subject (4).

Fowl paralysis.—Investigations into the etiology and mode of transmission of this disease are being carried out.

Intestinal worms.—Intestinal worms in poultry are proving a serious problem. No satisfactory treatment has yet been found. Advice on preventive treatment is being given to poultry farmers.

Titles of papers issued during the year.

1. Rice, J. P.: Avian diphtheritic enteritis and swine fever. *Veter. J.*, **87**, 1, 1931.
2. Lamont, H. G.: Laparatomy in a pullet. *Ibid.*, **87**, 1, 1931.
3. Kerr, W. R.: Poultry diseases. *Eggs.*, Aug. 12th, 1931.
4. Shanks, P. L., and Gordon, J. M.: Blood testing and egg production *Veter. J.*, **88**, 6, 1932.

G.

ANIMAL NUTRITION
and
ANIMAL BREEDING.

29. ANIMAL NUTRITION RESEARCH INSTITUTE, CAMBRIDGE UNIVERSITY.

Grasses.—During the past year Mr. F. W. Foreman has continued his investigations of the changes occurring during growth in pure cultures of grasses, especially perennial rye grass, and wild white clover.

The first series of examinations of perennial rye grass were made on specimens taken periodically throughout the season from a growth raised from seed sown in the spring. This growth reached a maximum in fifteen weeks from seeding time, but no inflorescences developed. Consequently an important part of the normal life history could not be covered in the first season's investigation. A general attack of rust (*Puccinia lolii*) commenced just prior to the maximum growth stage. The examinations were therefore continued in the hope of throwing light upon the factors influencing the rust development. The results give rise to interesting suggestions.

Similar studies of the changes during the development of the inflorescence and seed have since been added and the whole life history of one species of grass has now been covered. Attention has also been given to the question of how ammonium sulphate applied as top dressings affects the changes.

The data accumulated are voluminous and their interpretation requires much study. It is already clear that fluctuations in the contents of constituents embraced in this new scheme of enquiry are intimately associated with changes in the environmental conditions of temperature, sunshine, rainfall, manuring, etc., and with the stage reached in the life history. There is good evidence of storing for use in later plant processes. In some cases constituents of high importance in the plant metabolism and in the feeding value of the produce are subject to very wide quantity fluctuations.

Preliminary experiments with the foliage of wheat and barley suggest that similar investigations could be carried out with even less difficulty.

Changes occurring in the juices kept under aseptic conditions at room temperature and at 37° C, probably due to naturally occurring enzymes and the effects of proteolytic enzymes upon the insoluble constituents of the grass, have also been studied. The chemical identification of substances isolated at different stages in the growth is in progress.

Reasons for doubting the reliability of the method commonly used for estimating amides in plant extracts led to attempts to evolve a better method. This work has reached a promising stage.

Progress has been made in protein and amino-acid studies and an account of present-day views on protein chemistry in relation to animal nutrition has been published (1).

Nutritional aspects of the problems of pastures.—Dr. H. E. Woodman and his co-workers have continued their investigations. The first stage of the investigations into the influence of intensive fertilising on the yield and composition of pasturages has been completed and the results of the first two seasons of the work are in the hands of the publishers at the present time. In this paper by Dr. Woodman and Dr. E. T. Underwood important conclusions are drawn respecting the influence of periodic dressings of easily-available nitrogen on the yield and composition of good permanent pasture under the modern system of rotational grazing.

The series of investigations into the influence of the intensity of grazing on the yield, composition and nutritive value of pasture has been carried a stage further. The results of two years' work under a system of monthly cuts have been brought forward in a paper by Dr. Woodman, Mr. Norman and Mr. French (2). From these results it has been possible to work out the scientific principles underlying the nutrition of farm stock on rotationally-grazed pastures, an aspect of the question which has been further developed by Dr. Woodman in an article entitled " Pastures and Milk Production " (14). During the 1931 season, investigations have been prosecuted into these problems, a system of 5-weekly cuts having been adopted.

Dr. R. E. Evans has begun a series of investigations into the sulphur content of grass, and an article embodying the results of his researches on the cystine content of grass has already been published (15). This work is of special importance in connection with the problem of wool production on pastures.

Dr. H. E. Woodman is now making preparations to tackle the problem of the yield and feeding value of grass for winter grazing.

The investigations of Dr. Woodman and Dr. Stewart into the mechanics of cellulose digestion in the ruminant organism have now gone a stage further, and a paper embodying the newly-obtained results is in course of preparation for the press.

Beet pulp.—In conjunction with Mr. W. S. Mansfield and Mr. F. G. Garner, of the Animal Husbandry Section, Dr. Woodman has continued the investigations, under the auspices of the Beet Pulp Sub-Committee of the Ministry of Agriculture, into the value of dried sugar beet pulp and molasses beet pulp in the fattening of store cattle. A report of this work has been sent to the Ministry, and an article embodying the results of the whole of the investigations is in the press at the present time. As chairman of the new " Taint in Milk " Sub-Committee, Dr. Woodman has assisted in the formulation of proposals for investigating the cause of the tainting of milk by the use of beet molasses or beet molasses pulp in the rations of dairy cows.

During the past year, Dr. Woodman has written two bulletins which have been published in the series issued by the Ministry of Agriculture. The subjects of the bulletins are (*a*) home-grown feeding stuffs (9), and (*b*) oil cakes and extracted meals (10). During the writing of these bulletins, the economic needs of the present time have been kept in mind. Dr. Woodman has also been engaged with Mr. Arthur Amos in the revision of the Ministry's bulletin on Ensilage.

Calorimetry (Dr. T. Deighton).—The construction of a calorimeter for poultry, which was mentioned in the last report, was begun in the spring and will continue throughout the ensuing year. It is as yet too early to give any estimate of its success or otherwise ; the chief difficulty which is likely to arise is that of the sensitivity of the bolometers which may possibly prove insufficient to operate an automatic adjustment.

The water supply to the two large calorimeters is in process of being separated. At present they have to be run at the same temperature, and the separation will make it possible to have them running at different temperatures at the same time, which, it has often been felt, would be an advantage.

A beginning was made during the past year in the direction of working up for publication the material which has accumulated since 1929. It early became apparent, however, that the formulae commonly used for determining the surface areas of pigs left a very great deal to be desired, and that no useful progress could be made in the matter of metabolisms until this fundamental measurement could be established on a sounder basis. The work on the results was therefore temporarily abandoned and the energies of the department concentrated on the solution of the surface area problem.

In this they have, apparently, been quite signally successful and the results have been incorporated in a paper which will be published shortly. The new method of determination is there shown to be susceptible of an accuracy of 2 per cent. Unfortunately it cannot be applied to pigs already disposed of ; but it appears possible that the application of a modification of the formula of Hogan and Skouby or Cowgill and Drabkin to these cases will yield reasonably satisfactory results.

Physiology of reproduction and growth.—Mr. J. Hammond has been continuing his investigations. That into the fertility and reproductive phases in the mare has made good progress, and it is evident that, considered in relation to the end of heat, and presumably ovulation, the chances of a mating proving fertile vary greatly according to the time in heat at which the mare is served. Contrary to the usual belief it has been found that many mares will come on heat throughout the winter, and it has been shown that they can conceive when served in the autumn. The duration of pregnancy has been found to vary with the time of year the mare is due to foal ; in mares due to foal early in the season pregnancy is prolonged, while in those due to foal late in the season it is shortened, the extreme variations ranging over about a month. Rectal examination for the diagnosis of pregnancy is being tested.

Measurement of carcases at the Smithfield and Dairy Shows has been continued. A book on " Growth and development of mutton qualities in Sheep " is nearing completion and will shortly be published with the aid of funds supplied by the Empire Marketing Board. It deals with the experimental results of weighing lambs and the factors involved in flock management which affect the live weight growth of the animal. It also presents an account of the way in which the meat qualities of the animal have been produced, and gives an outline of the factors affecting the quality and edibility of meat generally.

The stock of inbred rabbits has been maintained for the study of fertility and growth problems. Two strains of low fertility (but low for different reasons—one owing to the small number of eggs shed and the other owing to the high foetal atrophy—have been crossed together and give high fertility does in the first generation. The number of eggs shed is intermediate and foetal atrophy is recessive in the first cross. This gives an explanation of the high fertility often found in the first cross, and the loss of fertility often associated with inbreeding in farm animals. Breeding tests and post-mortem examination of the ovaries and foetuses are being made on these strains and their crosses. Experimental studies on the factors which affect the weight of the young at birth and the duration of pregnancy are also in progress.

Experiments by Dr. A. Walton on the preservation of rabbit spermatozoa *in vitro* have shown that oxygen is harmful at low temperatures, and that for maximum survival, not only must semen be kept from exposure to the air, but the normal tension of oxygen must also be considerably lowered by saturation with nitrogen and 5 per cent. carbon dioxide mixture. The practical application of these results to domesticated livestock will be investigated in the near future. Experiments on the mechanism of ascent of the spermatozoon in the female genital tract have been carried out in collaboration with Dr. Florey of the Department of Pathology. This work has been carried out with the aid of a grant from the Empire Marketing Board.

Cow wastage.—Dr. H. G. Sanders continued his work on collecting data for the study of cow wastage until October 1, 1931, when the period of enquiry ended. The returns for the first two years have been collated and show extremely close agreement with one another. The average life of a dairy cow, in one and the same herd, in the eastern counties is 4½ years, and the main causes of disposal are sterility and failure in milking ability. The third year's returns, in conjunction with the other two, will, it is hoped, provide reliable information on the effect of various factors of herd management on wastage.

Poultry nutrition.—Mr. E. T. Halnan has been successfully continuing his work. During the past year an investigation of the role of protein in the fattening of birds has been undertaken. Commercial fattening mixtures have always contained high proportions of protein, and, since protein is a relatively dear food, it was considered desirable to ascertain by accurate experiment whether this inclusion of large amounts of protein was necessary. The results obtained have shown equally good fattening results from mixtures containing much smaller amounts of protein than those used in practice, a mixture consisting of 5 per cent. dried milk, 95 per cent. Sussex ground oats, giving as good results as one containing 20 per cent. dried milk, 80 per cent. S.G.O. These results have been confirmed by a test carried out on a commercial scale at Mr. Halnan's suggestion by the Southern Table Poultry Committee at Wye, Kent. Scientifically, the investigation was of extreme importance, since if the amount of fat produced by an animal was directly influenced by the protein present, the starch equivalent theory would have been shown to have been founded on false premises.

Dr. E. M. Cruickshank, continuing her studies on the physiology of fat formation, has obtained results indicating that a diet consisting of hemp seed, which contains a highly unsaturated fat, causes the fat of the egg to become more highly unsaturated, thus demonstrating that certain food fats may be deposited unchanged in the egg. On the other hand, a diet containing 30 per cent. mutton fat had no effect on the composition of the egg fat, although the body fat became markedly harder, showing that mutton fat may be deposited unchanged in the adipose tissue of the fowl. This work has been carried out with the aid of a grant from the Empire Marketing Board.

In a paper presented at the British Association on " Nutrition and the Hen " (17), Mr. Halnan gave data showing that, whereas from a meat production standpoint the hen is as economic a converter of feeding stuffs as the pig, from an egg production standpoint the hen is a much more wasteful converter.

During the year the new poultry premises have been built and most of the runs have now been put up—the remainder are in course of erection. Mr. M. S. Pease has made a start with the work on the new Cambar breed of poultry transferred from the Small Animal Breeding Institute. In addition Mr. Pease's rabbits have been moved into a new rabbit house on the new Institute side where he is now continuing his experiments.

Swine husbandry.—During the past year the series of experiments undertaken by Mr. A. W. Menzies-Kitchen and designed to determine the feeding value of tapioca and sago pith meal have been completed (16). The main conclusions are briefly summarised as follows :—(*a*) Tapioca meal is one of the most digestible feeding stuffs employed in swine husbandry and can be used as a substitute for barley meal up to 40 per cent. of the ration for fattening pigs. It exerts a favourable influence on the colour and texture of the carcase fat and on the quality of the bacon. Its use in pig feeding can be safely recommended. (*b*) Sago pith meal, a new carbohydrate feed imported from Malaya, can be used as a substitute for barley meal up to 20 per cent of the ration without depressing the rate of live weight increase. The most satisfactory results were obtained when it was fed to pigs over 100 lbs. live weight When fed in large amounts and for the small pigs it did not compare favourably with barley meal. (*c*) Sago pith meal plus a small addition of bran proved an efficient substitute for middlings. The results of an experiment investigating the value of lentil meal as (i) a partial substitute and (ii) a complete substitute for fish meal indicated that lentil meal plus a 1 per cent. mineral addition can effectively replace fish meal in a fattening ration provided that substitution takes place at the rate of two parts of lentils to one part of fish meal. During 1931 a further experiment was begun to test the value of ground oats as (i) a partial substitute for barley meal and (ii) a complete substitute for middlings. Favourable results were obtained and this work is being repeated in conjunction with an oat digestion trial carried out by Dr. Woodman.

Professor R. D. Sinclair of Alberta, who spent four months on a visit to the Institute, conducted some experiments on mineral metabolism on the same lines as those he had been carrying out at the Rowett Institute, Aberdeen. The same general trend of results was obtained. Pigs receiving an additional calcium ration showed a slightly higher level of blood calcium and corresponding lower level of phosphorus.

Titles of papers issued during the year.

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2. Woodman, H. E., Norman, D. B., and French, M. H.: Nutritive value of pasture. VII. The influence of the intensity of grazing on the yield, composition and nutritive value of pasture herbage—III. *J. Agric. Sci.* **21**, 267, 1931.
3. Menzies-Kitchen, A. W.: Developing of pig recording in East Anglia. *Camb. Univ. Agric. Soc. Mag.*, 1930.
4. ———: Economic aspects of pig recording. *J. Min. Agric.* **37**, 10, 1931.
5. ———: Pig recording in the future. *Nat. Pig Breed. Ann. Gaz.*, 1930.
6. ———: *Third report of the East Anglian pig recording scheme results* 1929-30. Dept. of Agric. Camb. Univ. Price 1s. net. Postage 2d.
7. Cruickshank, E. M.: Recent research work in poultry nutrition with special reference to the use of poultry mixtures. *Paper read at the 4th Ann. Surrey County Poult. Conf.*, Nov. 29th, 1930.
8. Halnan, E. T.: The scientific principles of poultry feeding. *Bull. No.* 7, *Min. Agric.* July, 1930. H.M. Stat. Off., Lond. Price 8d. Postage paid.
9. Woodman, H. E.: Home-grown feeding stuffs. *Bull. No.* 13 *Min. Agric.*, Dec., 1930. H.M. Stat. Off. Lond. Price 8d. Postage paid.
10. ———: Oil cakes and extracted meals. *Bull. No.* 11 *Min. Agric.*, Mar., 1931. H.M. Stat. Off. Lond. Price 7d. Postage paid.
11. ———: The role of cellulose in nutrition. *Biol. Rev.* **5**, 273, 1930.
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17. Halnan, E. T.: Nutrition and the hen. *Brit. Asscn. Adv. Sci.*, 1931.

30. ROWETT RESEARCH INSTITUTE, ABERDEEN.

Research on the physiology of nutrition is carried out in the Rowett Institute, and practical feeding experiments with farm animals on the Duthie Experimental Farm.

ROWETT INSTITUTE.

The influence of the nature of the diet on the chemical composition of blood and on immunological reactions.

This subject has been under investigation for several years. Previous work has shown that in growing rabbits on inadequate diets there appears to be a correlation between deficiency of calcium and fat soluble vitamins in the diet and the calcium and phosphorus level in the blood, and resistance to infection by the tubercle bacillus experimentally introduced. The work has been continued with groups of sheep kept under experimental conditions, and, also with larger groups on a sheep farm where the animals were under their natural environment and grazing on hill pasture which is known to be deficient, as compared to good pasture rich in calcium and phosphorus and probably in certain of the vitamins. In these animals, which are typical of most of the black faced sheep in Scotland, more abnormal levels of calcium and phosphorus were obtained than in the experimental animals at the institute, which were fed on a diet purposely designed to be deficient in these nutrients. Corresponding with the abnormalities in chemical composition, there were found to be abnormalities in certain immunological reactions. The assistance of Professor Mackie and certain of his staff at Edinburgh is being obtained in this investigation, the immunological work being done under his direct supervision (1, 2, 3).

This work is being continued along the following lines:—

(*a*) Groups of sheep are being fed on rations each with different deficiencies to ascertain the separate influence of various dietary factors in affecting the chemical composition of the blood and the immunological reactions.

(*b*) A series of balance experiments is being done with growing sheep to obtain further knowledge on the requirements of the growing sheep for various nutrients.

(*c*) In co-operation with the Torridon Wool Research Institution, observations are being made on these groups of animals on the influence of various dietary factors on the rate of growth and characteristics of wool.

(*d*) Data are being collected both on the small groups of animals at the Institute and on the larger groups of animals on the hills on the influence of different diets on clinical symptoms and on birth rate and death rate.

(*e*) Observations of a similar nature to those being made on sheep are also being made on pigs and on milk cows, though in these animals investigations are not so complete and comprehensive as in the case of sheep.

A study of the processes of digestion and absorption in farm animals.

This study was begun in 1926. It originated in observations made on experimental animals on inadequate diets. It was noted that in these animals intestinal disturbances were amongst the earliest symptoms, and post-mortem examination in some cases showed lesions in the intestinal tract. In guinea-pigs on certain deficient diets these lesions strongly resembled those found in the human in gastric or duodenal ulcers.

Work on the influence of ultra violet light and of some of the vitamins seemed to show that the beneficial effect of these might be to a large extent due to the fact that they help to maintain a normal and adequate absorption of certain nutrients through the mucous membrane of the intestine. These observations suggested that in animals on inadequate diets the first deviation from the normal might be found in the movements of the intestine and the processes of absorption by the mucous membrane.

Considerable progress has already been made with this study. It has been shown that the nature of the diet affects both the movements and the rate of absorption of certain nutrients. Last year an X-ray apparatus was installed to enable direct observations to be made on the movements of the intestine (4, 5, 6).

During the present year the following specific problems are being studied :—

(*a*) Influence of osmotic pressure on the emptying time of the stomach.

(*b*) Influence of the nature of the diet on the movement of the stomach in the ruminant.

(*c*) Fermentive changes in the rumen contents with special reference to changes in reaction and in the carbohydrates.

(*d*) Factors affecting the rate of absorption of foodstuffs with special reference to calcium and phosphates in lactation.

Study of the rôle in nutrition of minerals found in foodstuffs and animal tissues only in traces.

During the last few years a study has been made of iodine, sodium, potassium, aluminium, copper and manganese. In all these cases a review has been made of the literature, which was very scattered. Work has been done to confirm, or otherwise, results obtained by earlier workers, and further investigations made in the light of the advance in our knowledge of nutrition during the last twenty years. The work on manganese and aluminium has been brought to a close, as it is believed that the information obtained shows that no ordinary diet is likely to contain either a deficiency of these or an excess which would be harmful (8, 9, 10, 11, 12).

During the present year the main effort is being directed to work on fluorine and a continuation of the work on iodine. The work on iodine, in so far as it affects human beings, is being carried out in association with the Nutrition Committee of the Medical Research Council. A grant from this Council defrayed the cost of an investigation on goitre in human beings in Scotland and England, the results of which have already been published and reported.

The physiology of the fowl.

For the past few years a systematic study has been made of the physiology of nutrition in the fowl. An attempt is being made to correlate changes in the body as determined by biochemical and histological examination with the physiological changes during growth, onset of laying and moulting on birds both on adequate and inadequate diets. This fundamental research forms the basis for the practical feeding experiments with large groups of birds which are carried on in conjunction with the Ministry of Agriculture for Northern Ireland and the Glasgow and Edinburgh Colleges of Agriculture (21).

This investigation is part of a national scheme and the salary of one worker is at present defrayed by a grant received from the Empire Marketing Board.

Subsidiary researches.

(*a*) Work is being done on iron deficiencies and anaemia and on chloroform and ergosterol poisoning (15, 16, 17).

(*b*) A study is being made of the influence of diet on the action of insulin. The workers engaged on this are voluntary workers who are not on the paid staff of the Institute (7)

(*c*) Assay of halibut oil for vitamins A and D. This work is being done in conjunction with Professor Heilbron of Liverpool University and the Fish Research Station at Torry.

DUTHIE EXPERIMENTAL FARM.

On the Duthie Experimental Farm there are a number of animals on feeding experiments which are linked up with investigations referred to in the scheme of work for the Rowett Institute. Animals not required for this work are being used for experiments, such as those referred to below, to ascertain the best methods of applying recently acquired scientific knowledge in nutrition to problems of immediate practical importance.

In the Beef Cattle Department balanced meals are being substituted for milk to reduce the consumption of milk to a minimum, and thereby decrease the cost of rearing. During last winter it was found possible to rear calves successfully with less than forty gallons of whole milk. Tests are being done to ascertain whether it is more economical to milk the cows and feed the milk to the calves or to have numbers of calves suckling the one cow. Feeding experiments with animals past the suckling stage are being done to determine the most economic level at which to feed concentrates to beef cattle.

In the Dairy Department observations are being made on the effect of food on the colour of butter-fat, and feeding experiments are being done to elucidate the economic factors concerned with the relative value of hay and turnips for feeding for milk production. This is of immediate importance in view of the present laying down of arable land to pasture.

In the Pig Department experiments are being run in conjunction with the Lethbridge Station in Canada to determine the economic advantage of feeding cod liver oil to pigs in winter and feeding experiments are being run to ascertain whether certain waste products, e.g., oat dust, can be utilised in pig rearing (19).

In the Poultry Department a series of experiments is being run in conjunction with the Ministry of Agriculture for Northern Ireland and the Scottish Colleges. The most interesting part of this work is that dealing with the influence of minerals in the diet (21). It was found that a combination of all minerals, which were thought might be deficient, resulted in better growth, better health and increased egg yield. This further work is being done to determine by empirical tests which of the minerals produced this effect. It has been found that one of the most important is chlorine and that some of the other minerals used in the "grape shot" mixture are unnecessary for fowls kept under ordinary conditions. This work will enable mineral mixtures which are at present extensively used to be simplified and cheapened, and also enable the poultry feeder to make his own additions to the ration instead of having recourse to expensive proprietary mixtures.

In all these practical experiments being run on the farm, costings are being made so that the immediate economic value of different methods of feeding and management can be accurately assessed (20).

PASTURES RESEARCH.

The main work on pasture research is now being done at the Garrochoran sheep farm in Argyllshire. The nature of the deficiencies in the pasture on this farm has been determined, and they are believed to be generally similar to those in the poor grazings in the Western Highlands. A specially prepared feeding stuff containing the substances deficient in the pasture is being fed to some groups of sheep, and the rate of growth of lambs, fertility of ewes and mortality are being compared with those of sheep on similar grazing but not receiving supplementary feeding. Another test is being done to determine to what extent sheer starvation in winter is a factor in the high mortality. The cost of this work is being defrayed by a grant from the Empire Marketing Board.

POULTRY NUTRITION RESEARCH.

The research on poultry, which is being carried on under a special grant from the Empire Marketing Board, is being merged into the general work of the Institute as it is found that it will be possible to continue this work without asking for a renewal of the grant. The research work on the physiology of the fowl and the practical feeding experiments have been referred to above.

Titles of papers issued during the year.

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9. ———: The biochemistry of aluminium. II. Excretion and absorption of aluminium in the rat. *Ibid.*, **25**, 287, 1931.
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15. McGowan, J. P.: Subacute combined degeneration of the cord in primary anæmia of the fowl: Its pathogenesis and that of associated lesions. *Brit. Med. J.*, Aug. 9th, 1930.
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18. Fraser, A. H. H., and Middleton, W.: Milk lamb production in Scotland. *Scott. J. Agric.*, **14**, 3, 1931.
19. Crichton, A., Godden, W., and Thomson, W.: The value of dried potatoes for pig feeding. *Ibid.*, **14**, 1, 1931.
20. Davidson, H. R.: The most profitable weight for marketing pigs. *Ibid.*, **14**, 1, 1931.
21. Robertson, G. Scott, Orr, J. B., Prentice, J. H., and Macdonald, A. J.: Nutritive requirements of poultry. VII. Growth in chickens—III. *Ibid.*, **13**, 4, 1930.
22. Crichton, J. A.: The mineral requirements of dairy cattle. *J. Dairy Research*, **2**, 1, 1930.

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31. (CHEMICAL AND) ANIMAL NUTRITION DIVISION, MINISTRY OF AGRICULTURE, FOR NORTHERN IRELAND.

Poultry nutrition.

Chicken rearing.—The results of experiments conducted last year showed that the absence of chlorides of sodium and potassium from the mineral mixture in rations for growing, chicks caused a considerable depression on the rate of growth. This was confirmed in a similar experiment this year, and in addition it was shown that there was no comparable depression in growth rate when potassium carbonate and sodium bicarbonate were substituted for the corresponding chlorides in the mineral mixture. In another experiment it was demonstrated that sodium chloride gave satisfactory results when used in the mineral mixture in place of the mixture of potassium and sodium chloride. The results indicated that sodium and/or potassium are at least as essential as chlorine.

The addition of extracted soya bean meal to a cereal ration did not result in an increased rate of growth, but a further addition of a mixture of sodium chloride and potassium chloride gave as good results as the addition of the "complete" mineral mixture.

In all the above experiments the chicks had access to crushed oyster shell, and, apart from this, common salt appears to be the only mineral substance which is likely to be lacking under normal ditions of farm practice.

Laying experiments.—Experiments with laying birds, in which the relative importance of the mineral ingredients has been examined, have given similar results to those obtained with the feeding of chickens.

The calcium and phosphorus balance experiments with laying pullets have been continued, and it has been established that egg laying is coincident with a temporary, discontinuous, and rather heavy negative phosphorus balance, and that calcium excretion tends towards a uniform low level during egg production. A paper embodying these results is in the course of publication.

Composition of milk.

The statistical work in connection with the inquiry into the variation in the composition of the milk from dairy cows is still proceeding. An account of the influence of stage of lactation on the natural acidity of milk has been published (1), and a report dealing with the influence of season and temperature on yield and composition has also been prepared. It has been shown that the season exerts a marked influence on the percentage of solids-not-fat, and that during periods of high temperature the percentage of solids-not-fat is depressed whilst the influence of temperature on butterfat percentage is comparatively insignificant.

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2. Common, R. H.: The rationing of baby beef. *J. Min. Agric. N. Ireland*, **3**, 34, 1931.
3. Prentice, J. H., and Baskett, R. G.: Notes on the fattening of surplus cockerels. *Ibid.*, **3**, 29, 1931.
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6. Baskett, R. G.: Nutritional factors influencing the growth of chickens. *J. Min. Agric. N. Ireland*, **3**, 5, 1931.
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32. PIG HUSBANDRY EXPERIMENT STATIONS.

(A) HARPER ADAMS AGRICULTURAL COLLEGE.

The principal experiment of the year has been a further test of the normal variation in lots of ten pigs when fed alike, and managed in accordance with the standard routine followed in the experimental work of the piggery. This experiment comprised 50 pigs, housed in fives, but treated as five lots of ten pigs each, the pigs being distributed through the five lots with the usual precautions to ensure comparability. The average live-weight gains of the lots for a period of 20 weeks showed a range of variation rom 151·4 lbs. to

165·8 lbs. per pig. The degree of variability was higher than in the previous test made on the same lines.

A further experiment has been completed on the subject of the optimum proportion of soya meal required to " balance " a basal cereal diet. The results were entirely confirmatory of previous experience, but the results of a further experiment in progress are awaited before a final pronouncement is made.

The question of the water requirements of the pig has been examined, and the results indicate that an allowance of three parts of water to one part of meal is ample for young pigs, and that the proportion may be substantially reduced as the pig grows.

The protein studies will be rounded off by another experiment now well under way in which soya meal is being compared with a mixture of five different highly nitrogenous foods.

(B) SOUTH EASTERN AGRICULTURAL COLLEGE, WYE.

Gilts reared on the open air system were compared with similar gilts housed in styes and allowed out to graze when conditions were suitable ; no differences were observed either in the growth of the gilts or in their offspring.

Excellent results have been obtained by feeding rations with a comparatively low protein content to in-pig sows (1, 2).

It has been shown that it is easier to rear sucking pigs which have access to a grass run than those confined to styes, provided precautions are taken to control parasitic worms. The former pigs make more growth and suffer less from digestive troubles (4).

A mixture of wheat meal and bran was found to make a satisfactory substitute for middlings in the ration of growing and fattening pigs (5).

It was found possible to increase the proportion of middlings up to 60 per cent. in the ration of pigs which were allowed to run out on grass during the first twelve weeks of the feeding period without appreciably decreasing the rate of growth (3).

Titles of papers issued during the year.

1. Fishwick, V. C. : Rations for in-pig sows. *J. Min. Agric.*, **37**, 7, 643, 1930.
2. ——— : Feeding and management of breeding pigs. *Agric. Prog.*, 1931.
3. ——— : Middlings in pig mixtures. *Farmer and Stockbreeder.* Oct. 12th, 1931.
4. ——— : Rearing sucking pigs. *J. Min. Agric.* **38**, 9, 898, 1931.
5. ——— : Wheat meal *v.* millers' offals. *J. Min. Agric.*, **38**, 8, 790, 1931.

33. NATIONAL INSTITUTE OF POULTRY HUSBANDRY, HARPER ADAMS AGRICULTURAL COLLEGE.

Statistical studies.

Methods of estimating annual egg production and egg weights which dispense with the daily trapnesting and weighing of eggs laid by a flock of birds have been studied, and a preliminary report made in a paper read at the Harper Adams Annual Poultry Conference, 1931 (1). The methods investigated were (*a*) trapnesting and weighing on only the four middle days of every lunar month and (*b*) trapnesting and weighing on Fridays only. The methods can be of service in giving a reasonable approximation to the annual production and average annual egg weight of individual birds. They also constitute a marked improvement on the use of winter, spring, or summer records, leaving, however, considerable scope for the exercise of skill and discretion on the part of the breeder. This work has been continued, and a separate report will be prepared of the results of a further study of the records of the Harper Adams Egg Laying Trials. A very slight positive correlation has been found between production and egg weight, indicating that the greater the production the greater the egg weight.

The results of the 1929 experiments and a summary of the entire experiments to date at the Northern Breeding Station at Reaseheath were prepared and a paper by W. B. Mercer, based on these results, has been published (2).

The results of the Southern Table Poultry Experiments at Wye, including data on the live weights of Light Sussex at four stages of growth and the increase in live weight from one stage of growth to the next, are being analysed.

Hens' eggs : egg quality studies.

Yolk colour.—The addition of ½ per cent. of red pimento pepper to the all-mash ration increased the percentage of dark yolks. Iron oxide added at the rate of ¼ per cent. decreased the percentage of dark yolks. Grain and mash feeding gave a larger proportion of light yolks and a greater range of yolk colour than the all-mash rations. On the same rations, there is a considerable amount of variation in the yolk colour of different individual fowls.

Condition of white.—Preliminary observations indicate that the individual, the season, the intensity of production, and shell texture may all be factors in " watery white " eggs, and that the protein content of the ration probably has little effect upon it. Further data from pens getting various rations are being collected.

Shell texture.—The feeding of mussel shell in place of oyster shell results in equally good shell texture, according to the observations of the candler.

Egg weight.—The influence of various rations on egg size is being further studied.

Ducks' eggs. The observations on shell texture, condition of albumen, and yolk quality of eggs from ducks fed on meat and bone meal or fish meal have not progressed sufficiently to be able to state indications. An attempt to preserve duck eggs from the two pens resulted in failure, as many eggs were not considered to be edible when removed from the preservative.

Battery brooder experiments (3 *and* 4).

Variation in protein content of ration.—Chicks fed on a high protein ration for the first four weeks grew slightly, but not significantly, faster than those fed on a medium protein ration, not only to four weeks, but also to eight weeks. Chicks fed on a low protein ration made much less rapid growth to eight weeks than when fed to that age on a high protein ration.

Maize meal versus wheat bran.—A ration with 49 parts of bran and 30 parts of maize meal did not give any better results than a ration with 30 parts of bran and 49 parts of maize meal. The addition of 20 per cent. of bran to the standard ration at two weeks appeared to check leg trouble.

Maize meal versus thirds.—When a ration with 48 parts thirds and 14 maize meal was compared with one containing 48 parts maize meal and 14 thirds, the growth was similar, but the thirds pens feathered slightly better.

Battery versus colony rearing.—There was no significant difference at 8 weeks or 18 weeks between battery and colony stove reared chickens.

Simple versus complex rations.—A number of rations with a great variety of foods failed to give more satisfactory results than the simple standard Institute ration, and in some cases gave less rapid growth and more leg trouble.

Mineral studies.—A comparison of the standard ration with the same ration minus ground limestone, minus bone flour, and with neither mineral food resulted in a significantly lower growth in the pen not getting bone flour. The feathering, however, was best at eight weeks in this pen and there was less leg trouble. There was more serious leg trouble when the mineral content of the rations was high than when it was low.

Supplementary foods.—The addition to the standard ration of 10 per cent. of dried skim milk and 10 per cent. of yeast gave equally good growth, which was significantly better than that for the standard ration or the ration in which 10 per cent. of alfalfa meal had been added to the standard mixture. The addition of 5 and 10 per cent. of dried skim milk to the medium protein ration gave definitely better growth, slightly less leg trouble and about as good feathering as the medium protein ration.

Table poultry experiments.

Chickens that have been started in battery brooders and have made a relatively rapid rate of growth to the fattening stage have not fattened well either when trough fed only for 18 days or when trough fed for 12 days and fattened for 6 days. Preliminary observations indicate that they do better if left in the pens. Significantly greater gains have not been obtained by cramming over trough feeding and cramming. Equally good results have been obtained in the fattening batteries as in the usual crates. The fattening crates were found more convenient for cramming, but required greater floor space.

Table duck experiments.

Egg production.—Meat and bone meal has given as good egg production in a ration for ducks as fish meal, and the cost of feeding it is less. The fish meal pen gave somewhat larger eggs. A report will be issued soon on this experiment, which has extended over two years.

Table duck production.—From the results that are available to date, barley meal seems to be better for fattening ducklings than Sussex ground oats, and is also cheaper.

Turkey production.

Late hatched turkeys were successfully raised intensively to 24 weeks of age and averaged about 13 pounds in time for Christmas. Intensive rearing was not found to eliminate blackhead infection entirely.

Incubation studies.

A report of abnormalities of dead-in-shell has been published (5) giving some interesting statistical information concerning this serious problem. The results indicate that methods of turning or handling of eggs during incubation require extensive experimental investigation.

Wire floors for chickens.

A report of observations on the use of wire floors for poultry has been published (6) and reprints have been distributed.

Summer range shelter.

A report dealing with an inexpensive range shelter that is ideal for healthy development has also been published (7).

Titles of papers issued during the year.

1. Dudley, F. J.: Short period trap-nesting as a means of estimating annual egg production and average annual egg weight. *Harper Adams Utility Poult. J.*, **16**, 11, 1931.
2. Mercer, W. B.: Effects of in-breeding. The Northern Breeding Stations Committee's experiments. *Ibid.*, **16**, 11, 1931.
3. Parkhurst, R. T.: Possibilities and problems in battery brooding. *Ibid.*, **16**, 6, 1931.
4. McMurray, Mary R.: Battery brooding. *Ibid.*, **16**, 11, 1931.
5. Hale, H. P.: Some abnormalities of dead-in-shell. *Nat. Inst. of Poult. Husbandry. Leaflet No.* 15. Aug., 1930.
6. Parkhurst, R. T.: Wire floors for chickens. *Harper Adams Utility Poult. J.*, **16**, 6, 1931.
7. Parkhurst, R. T., McMurray, Mary R., and Fogden, E. W.: A summer range shelter. *Ibid.*, **15**, 8, 1930. *J. Min. Agric.*, **38**, 6, 1931.

34. SMALL ANIMAL BREEDING STATION, CAMBRIDGE UNIVERSITY.

Further progress was made on the inheritance of fecundity in poultry.

Experiments were made with ducks towards the further elucidation of the sex-linked down character discovered last year. The object of the work is the formation of a breed of runner ducks which will give the sex-linked result on crossing with the Fawn or Fawn-and-White. There is good reason for supposing that this will be accomplished in two to three years.

Experiments are also in progress dealing with the mode of inheritance of certain coat colours in rabbits.

35. INSTITUTE OF ANIMAL GENETICS, EDINBURGH UNIVERSITY.

Investigations at this Institute have continued along the lines indicated in reports on previous years. So far it has not been found possible to obtain the additional endowment which would permit of full extension of the Institute's activities at its new farm. Work, however, is being done with the available material, and the farm stock has been selected to fulfil the double function of being at once animals of commercial value and appropriate material for current investigations.

Cattle.

Inheritance of milk yield.—For the past few years the principal subject of investigation by workers in the Department of Animal Husbandry has been the conduct of an enquiry into the inheritance of milking capacity in dairy cattle. This line of research was the outcome of a systematic series of genetic studies concerning the different breeds of livestock initiated in the year 1925. In the year 1927 an examination was made of the Jersey cattle breed in England. This led to the elaboration of the hypothesis that certain of the factors governing the inheritance of milking capacity might be transmitted in a sex-linked manner. In the same year another study, this time into the Ayrshire breed, was inaugurated, and the results published in 1929 tended to confirm this hypothesis. These results have been mentioned in previous reports and have been already published.

The methods employed in these two investigations, modelled upon those used by workers in other countries, were found to be unsatisfactory. The statistical premises on which they were based left much to be desired. The major fault was that the phenotype of the individuals of the generation under observation was compared not with the phenotype but with the genotype of their ancestors. Accordingly, using the same data already employed in the study of Ayrshire cattle, a new method of attack was initiated. Dr. R. A. Fisher, of Rothamsted, who had already been invaluable in guiding previous investigations, suggested the method of the new enquiry. Briefly, in place of correlating the yields of individuals with their various ancestors, the values of the ancestors are measured by the difference in the yields of individuals connected by one or more common ancestors, the common ancestor (or ancestors) appearing in the same place in the pedigree of each individual. The differences in the yields of over 56,000 pairs were examined in respect of total yield and total butter fat yield, and the results were communicated to the Breeding Section of the International Dairy Congress held in Copenhaen in July, 1931 (32). Briefly stated these results appear to show that, while transmission of the total yield of milk is to some extent dependent upon factors transmitted in a sex-linked manner, total yield of butter fat would appear to be dependent solely on autosomal factors.

In this paper the general problems of the inheritance of milk yield were stated. *A priori* neither yield nor quality can be inherited in any simple manner ; neither can the genes act principally in a dominant or recessive manner. Accordingly it is important to ascertain whether or not any genes governing the inheritance of milking capacity are transmitted in a manner which does not conform to classical mendelism. That inbreeding has been so little employed in the construction of the dairy breeds might be taken as an indication that certain of the factors governing the transmission of milking capacity were inherited in a peculiar manner. Up to the present time the investigations clearly show that this possibility cannot be ruled out.

This study is being continued, using the Dairy Shorthorn as material, work on which was begun in October, 1930. The data have been provided by twenty of the leading Dairy Shorthorn breeders in England and include not merely high producing cows, but every animal in the herd. In this respect the present investigation is unique, and it is not altogether anticipated that the results obtained from it will confirm in every way the results previously obtained here and elsewhere by studies confined to high yielding animals. Up to the present no analysis of the data has been made. Before this a considerable amount of spade work has to be done. The yields of the cows have to be corrected for age, etc., their pedigrees have to be looked out in the herd books, and the individuals classified according to their ancestry.

With the establishment of the Experimental Farm at Shothead, opportunity has been provided for the testing of this hypothesis in a practical manner. Three herds of cows are maintained. The first two are of the same breed, Shorthorn. The Dairy Shorthorns are being mated to a beef Shorthorn bull of a strain which has given but little milk. Similarly, beef Shorthorn cows are being mated to a proven Dairy Shorthorn sire. Cross-bred bulls thus obtained will be tested upon the herd of Ayrshire cows. The relative extent by which they depress the yields of their daughters as compared to the yields of the cows to which these bulls are mated should give some indication of the inheritance of milk yield. Such an experiment has never been conducted in any part of the world.

The attention of many workers in various parts of the world has been drawn towards this subject of inheritance of milk yield, and within the past twenty years a considerable body of literature has appeared bearing upon this subject. No analysis of this literature has been published. Accordingly, during the year, a complete survey of this literature has been made, stating the methods employed by the various investigators, particularly in the United States and in Germany, and giving their results in a concise form and with critical notes. Thanks are due to the Imperial Bureau of Animal Genetics for their assistance in this review.

An additional enquiry into the inheritance of milk yield is under way, based upon data published by the Danish livestock authorities in connection with the improvement of dairy herds in that country and the use of progeny tested sires. The preliminary results of this investigation tend to confirm the previous findings that milk yield, but not butter fat yield, is to a certain extent conditioned by sex-linked factors.

Conformation and yield.—With the cattle at Shothead it is intended to study the relation of conformation to milking capacity. In this connection the Institute welcomed a visit from Dr. Graves, head of the Bureau of Dairy Industry, United States Department of Agriculture. The outcome of this visit was the welcome offer of co-operation by the Bureau of Dairy Industry. The Bureau are lending us the requisite instruments, etc., for measurements and are giving us instructions as to how these measurements should be made whereby the results obtained at Shothead may be compared with those obtained by the Bureau at the fourteen farms and twenty herds throughout the States.

Cow and bull wastage.—The rate of replacement of heifers in cattle herds is of considerable importance, and not least from the genetical aspect. An enquiry was commenced in 1925 into the average ages of cows in the various breeds of cattle, the results of which were published in the year under review. It was found that the average replacement figure is in the neighbourhood of 25 per cent.

Similarly, a study was made of the average ages of bulls, as this also has considerable bearing upon the improvement of both dairy and beef breeds. This was found to be extraordinarily low, the average length of the productive life of a bull in a pedigree herd being around 18 months (33).

Inheritance of markings.—An examination of the records of white markings in the Belted Galloway confirmed that the belt is inherited as a simple dominant and that there is a correlation between an extended belt area and the possession of white socks. The extension of the area and the appearance of white socks appears to be dependent upon several genetical factors.

Lactation studies.—Several investigations made by workers in the Institute have suggested that the anterior lobe of the pituitary is responsible for the inception, and probably also for the continuation, of lactation. In particular two enquiries may be cited : the injection of certain extracts of the anterior lobe of cattle caused apparently normal lactation in virgin rabbits to occur within a few days : secondly, implantation of anterior lobe substance incited complete lactation in normal rats. Greuter and Frey have shown that a similar effect can be produced in cattle. The extracts prepared in this laboratory have now attained a considerable degree of purity· Unfortunately, owing to lack of funds, it is not possible to concentrate upon this work.

HORSES.

After a temporary abeyance the work on the Clydesdale breed has been renewed as part of the series of genetical studies previously mentioned. During the past five years the degree of inbreeding in stallions has decreased slightly while that of mares has increased, the breed as a whole being slightly more inbred.

The purpose of these breeding studies is to establish the norm of the breed to which specific groups of animals can be compared. It has been found that prize-winning Clydesdales are consistently and appreciably more inbred than the average of the breed. The higher the place the stallion may take the higher is the likelihood of its being inbred.

The pedigrees of stallions refused licences under the Stallion Licensing Act of 1918, since they were possessed of certain defects, were also examined. It was found that those suffering from stringhalt were significantly more inbred. In no other class was there obtained a difference statistically significant. Nevertheless it was found by an examination of the individual blood lines that some of the defects were almost certainly due in part at least to genetic circumstances. Amongst these were roaring, sidebone and ringbone, while the evidence was not so clear in respect of shivering and whistling.

A further study was conducted into the methods employed in the construction of the famous stud of the late Sir John Gilmour, Bt., of Montrave.

A stud of Shetland ponies is being maintained at Shothead for the study of physiological problems relating to the reproductive cycle of the horse (15).

PIGS.

With the removal of the pig work from West Mains to Shothead the Testing Station was closed down, and owing to the outbreak of disease in the neighbourhood (swine fever and foot-and-mouth) the work was not re-commenced when the new buildings at Shothead were completed. The principal object of the scheme was to discover the relative efficiency for bacon production of strains, breeds and crosses, the tests being conducted under standardised systems of feeding and management in order that differences primarily of genetic origin might be accurately assessed. The results were grouped under (*a*) prolificacy, (*b*) economy and live weight increase, (*c*) rate of live weight increase and (*d*) quality of carcases. Much useful information was obtained regarding the type of pig most suitable for bacon production and the relative effect of breeding and nutrition on carcase quality. As a result of running the Testing Station an effective liaison has been made between investigators and producers, and it has been found that there is a widespread adoption of our findings by breeders throughout Scotland.

When the new pig houses at Shothead were opened they were stocked with pedigree Large Whites selected from strains which gave the best results in the Pig Testing Scheme. The results of the Testing Station had shown that the difference was as great between strains within a breed as between breeds. Accordingly it was decided that it would be advantageous to study the genetic variability of one breed, and this is being done along the following lines, (*a*) prolificacy, (*b*) economy and food conversion, (*c*) rate of growth, (*d*) measurements of conformation of the live pig and (*e*) quality of carcases and carcase measurements. The stock in addition to being of value for experimental purposes is being used as a basis for effecting improvement of type in the selection of the breeding stock.

The Scottish Bacon Pig Competition was continued and, as in previous years, conducted under the joint auspices of the Highland and Agricultural Society and this Institute.

POULTRY.

Poultry genetics.—The analysis of sex and sex characters in poultry still forms a subject of study. The problem is being attacked from two different angles :—

(*a*) by the implantation of extra gonadal tissue into complete birds ; and

(*b*) by the injection of sex-hormones.

A preliminary study of the results obtained from the implantation of testis into the normal hen led to the following tentative conclusions:—(i) that the degree of development of the reproductive gland is not limited by its own potentialities but by some factor outside the gonad itself ; and (ii) that high fecundity, for instance, is dependent on the influence of physiological factors acting upon the ovary. The results obtained from birds with good testis grafts showed that among other things sexual maturity was greatly retarded, and that rate of egg production and total number of eggs were adversely influenced.

In the period under review further investigations of a similar type have been carried out and the large amount of data accumulated is now being analysed. In 1929 it was considered that a thorough investigation into the normal growth and development of the body and of the endocrine organs should be attempted in order that the deviations from normal functioning due to experimental interference could be accurately assessed. Although collection of sufficient data for this purpose was expected to entail some years' work, already a preliminary examination of the available figures leads to suggestive hypotheses on the effect of time of hatching and season on body changes, particularly in regard to reproductive functioning.

Another piece of work shows that, contrary to the findings of Soli, the thymus gland is not primarily responsible for the production of the shell of the egg. Following the extirpation of the gland from laying hens no eggs with faulty shells were produced (20).

In conjunction with Professor Dodds, of the Middlesex Hospital, London, several pieces of work have been undertaken with a view to standardising the male hormone. A preliminary study showed that an indication of the effect could be obtained by measuring the combs of capons into which the testis extract had been injected. It was also found possible to obtain the active principle in a water soluble form. Further work deals with the qualitative examination of the properties of the factor promoting comb growth (21). Lastly, an experiment using a large number of capons was carried out in order to examine its quantitative effect. It was shown that the standardisation of testis extract presents great difficulties. Owing to individual idiosyncrasies of the birds it is not possible to use small numbers for quantitative experiments ; also with increasing doses the effect of the extract becomes diminished.

An interesting corollary to the work of Juhn and others (who showed that the injection of Oestrin into males produced female plumage) was obtained in the case of two capons injected with a water soluble preparation of Oestrin. In this case the plumage changes thus brought about suggested those obtained in cases of hyperthyroidism, and were interpreted as being an intermediate stage in a process leading to the complete feminisation of the feathers. From this it is concluded that Oestrin acts firstly in stimulating the thyroid gland and only with increasing doses can the complete sex change in the feathers be produced.

Other studies relating to the sex physiology and genetics of the domestic fowl include :—

(*a*) The effects of X-rays on the testis are being examined with a view to defining the physical basis of the secondary gonadic characters and sexual behaviour (25).

(*b*) An attempt is being made to study the factors which underlie egg laying and broodiness by observation of the effects of injections of anterior pituitary upon the immature hen.

(*c*) The influence of the anterior pituitary and of the thyroid upon the developmental capon and poularde continues to be the subject of observation.

(*d*) A purely genetical study of the Arauncuna is being carried out. The Arauncuna lays a blue egg and it is found that the F_1 ex Light Sussex and Arauncuna has the same characteristic. An F_2 is now being raised.

Turkeys.—Genetic studies of plumage colour in the turkey are being continued.

(*a*) In a study of the relation of Bronze to Black, Blue, Red and White it has been demonstrated that Bronze is dominant to Red and to White and recessive to Black and to Blue.

(*b*) A further study of the relation of Black, Blue, Red and White is still in progress.

Ducks.—The genetics of plumage colour in the duck is also being investigated.

An F_1 ex Aylesbury and Muscovy
Rouen and Pekin
Black Runner and White
Dark Fawn and Light Fawn
Chocolate and Light Fawn
Black and Light Fawn
White Muscovy and Blue
White Muscovy and Magpie

has been raised and during the present season an F_2 and back crosses will be bred.

RATS.

A repetition of Professor MacDougall's experiment on the inheritance of educability in the rat is being conducted at this Institute. Professor MacDougall, the eminent psychologist, reached a revolutionary conclusion in this matter. As a result of teaching rats to perform a specific task for many generations he claims, with reason, to have induced inheritance of a specific modification in behaviour. It was thought most desirable that this study should be repeated and during its course close contact has been maintained with Professor MacDougall. Results obtained here seem to conflict with those previously obtained by Professor MacDougall, but as yet the position is not clear.

MICE.

The growth rates of the mouse during the periods from birth to weaning and from weaning to puberty are being observed. Other studies include the genetics of a new mutant character "wavy," the histology of the skin of the "hairless" mouse (18), the effects of vasectomy on libido and the remote effects of long continued abstinence on the male.

DROSOPHILA OBSCURA.

"Snapt," a new mutation, is being studied intensively. The mutation is of considerable interest for the reason that the expression of the character exhibits a peculiar sex dimorphism (13).

The effects of temperature and X-rays on the mutation rate are being investigated.

RABBITS.

The rabbit stock has been considerably increased, and more commodious quarters have been found for them in a building which was formerly a piggery but which, through the gift of the National Rabbit Council, it has been possible to transform into a serviceable rabbitry.

The study of feeding a diet rich in cystine has been continued in co-operation with the British Wool Research Association, Leeds. Results so far obtained do not appear to indicate any beneficial effects (40).

For some years records have been kept of the effect of certain factors upon litter size, duration of pregnancy, sex ratio and fertility of coitus. The end of this task is not yet in view but an interim report has been issued (39).

It has often been alleged that the Rex rabbit inherits liability to certain diseases. This allegation is now being carefully scrutinised and the inheritance or non-inheritance of rickets and malformed eyelids is being investigated. In conjunction with this the inheritance of different types of coat fur found in the Rex is being examined. Particular attention is being paid to the plush and harsh types of coat. These studies are still in their initial state, but there seems to be no difference in the vigour characteristic of both types.

It appears that there are two types of Chinchilla, the dark being dominant to the light, and the heterozygous form differs from the pure or homozygous. This is in agreement with the conclusions of Castle, but so far it has not been possible to identify the Marder Chinchilla type recorded by Nachtsheim. The analysis of this series of allelomorphic characters is of some considerable importance to breeders as in their combination with the self or tan pattern character the sable varieties are produced. These are amongst the most popular and therefore the most profitable varieties of furbearing rabbits. Their value, however, has been reduced by the fact that only a small proportion of the animals bred are of the light shade which at present is the most popular. It is believed that if the series involved is

C .. Ordinary Full colour
c^{chD} .. Dark Chinchilla
c^{chL} .. Light Chinchilla
c^{H} .. Himalayan
c .. Albino

the types when combined with tan pattern factor ($a^{T}a^{T}$) are as follows :—

$c^{chD}c^{chD}$ .. Silver Fox.
$c^{chD}c^{chL}$ .. Very dark Sable and almost if not entirely indistinguishable from a "bad coloured" Silver Fox. A single dose of the dark chinchillation factor appearing to hide the effect of even the Albino factor.
$c^{chL}c^{chL}$ .. Dark Sable.
$c^{chL}c$ .. Medium or Light Sable—the exhibition type.
$c\ c$ .. Albino.

Another purely genetical line of work is the production of a variety exhibiting as many recessive characters as possible. This breed, when established, will prove not only useful as a pelt, but will also breed true and be invaluable for testing the homozygosity of other stock.

SHEEP.

Physiology of wool growth.—The study of the influence of the thyroid gland upon wool growth has been continued. The method of procedure has been to compare in detail the characters of the wool grown after thyroidectomy with those exhibited before the operation and with those shown after the administration of thyroid extract. The detailed physical examination of the samples was carried out by the Wool Industries Research Association, Leeds, and their examination suggests that the thyroid is responsible for the maintenance of activity of the cells in the wool follicle before keratinization occurs. It is further suggested that deficiency of thyroxin results in a decrease of (*a*) fibre thickness, (*b*) density of number of fibres per unit area, and (*c*) breaking stress of the wool. Under the same condition elasticity and tensile strength seem to be increased, but growth in length is not affected.

An examination of the effects of pinealectomy on wool growth is now under way, but no results have yet been obtained. The investigation is still in its initial stage.

Physiology of reproduction.—During the year under review studies of the physiology of reproduction in the ewe have had special reference to the changes which occur in the cell content of the vaginal smear during oestrum. The intention is to determine the peak of oestrus, the time relationship between coitus and ovulation and variation of pregnancy of oestrus under differing environmental and seasonal conditions.

The embryology of the uro-genital system of the sheep has also been a subject of investigation. Some difficulty was experienced in obtaining embryos at the earlier stages of operation. This difficulty has now been overcome, but it has not yet been found possible to ascertain at what stage in foetal development sex differentiation in the sheep takes place.

Genetics.—Studies under this head fall into two groups.

The first group comprises an examination of the mode of inheritance of various deformities. Examples of these include fibrosis of muscle in lambs, to which reference has been made in previous reports. Other deformities under investigation are jawlessness in lambs and the absence of nipples in ewes. During the year small flocks of ewes have been collected and are mated with rams. Each individual of these flocks has been selected on a basis of either exhibiting or being heterozygous for a particular deformity. Heterozygosity has been determined by a study of the previous breeding history.

The second group of genetical studies relates to the mechanism of inheritance of face colours of Blackface sheep and their correlation, if any, with characters of economic importance. Through co-operation with flock owners scattered throughout Scotland, data relating to over 2,000 sheep are now available. It is not yet possible to form any definite conclusions and the study is being continued. Concurrently with this work an attempt is being made to correlate varying proportions of black and white in the wool with hardiness and milk yield in the ewes. There is strong evidence that such a correlation does exist.

In previous reports reference was made to the study of kemp percentages in the fleeces of breeding sheep. It is now possible to select a site on the sheep's body for sampling which will give much more accurate kemp percentage results than could previously be obtained. Progress has also been made in the invention of a special apparatus for the estimation of kemp percentage on the basis of clean dry weights of kemp and non-kemp fractions.

Pigmentation.—A beginning has been made of a general study of pigmentation in animals with special references to the sheep. The subject has been approached from different angles.

A detailed survey of colour changes in Suffolk lambs was carried out. The purpose kept in view was the determination of the modes of deposition and the disposition of the pigment in the wool fibres. It was found possible to define these accurately. The phenomenon of white banding in coloured wools was also examined, and the arrangement of fibres responsible for the appearance of the bands was determined. Strong circumstantial evidence suggests that the periodicity of the banding, in some animals at least, was due to a periodicity in the intake of protein. A diet rich in protein resulted in the appearance of a pigmented band, while one in which protein content was low induced the appearance of a colourless band in the fibre. The evidence, however, is not entirely conclusive, and the matter is being further investigated.

Titles of papers issued during the year.

1. Crew, F. A. E.: *An introduction tc the study of sex.* Victor Gollancz. (In the press.)
2. ————: *A review of the effects of alcohol on man* (contribution to). Victor Gollancz, 1931.
3. Boyd, E.: Colour banding in fleeces. *J. Text Inst.*, **21**, 6.
4. ————: Studies on skin transplantation in mice. (In the press.)
5. ————: A histological survey of pigmented fibres in the Suffolk fleece. (In the press.)
6. ————: The dopa reaction and its application in studies of animal pigmentation. (In the press.)
7. Burns, R. H.: Monthly wool growth of Rambouillet ewes. *J. Text. Inst.*, **22**, 2, 1931.
8. ————: Monthly wool growth studies II. *Ibid.*, **22**, 9.
9. Crew, F. A. E.: The assumption of the male plumage by the hen pheasant. *Vet. Rec.*, May 9th, 1931.
10. ————: Biological aspects of migration. *Bull. Internat. Pop. Union.* (In the press.)
11. ————: The genetic background of mental defect. *Eug. Rev.* (In the press.)
12. ————: Genetic methods of livestock improvement. *Bull. Imper. Bur. An. Genet.* (In the press.)
13. ————: A sex-linked recessive lethal in *Drosophila obscura. J. Genet,* (In the press.)

14. Crew, F. A. E.: A case of leg colour asymmetry in the fowl. *Ibid.* (In the press).
15. Crew, F. A. E., Miller, W. C., and Anderson, J.: A brief note on the diagnosis of equine pregnancy by biological test. *Vet. J.*, **87**, 10.
16. Crew, F. A. E., and Mirskaia, L.: The effects of density on an adult mouse population. *Biol. Gener.*, **7**, 2.
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18. ——— ———: The character "hairless" in the mouse. *J. Genet.* **25**, 1, 1931.
19. Greenwood, A. W., and Blyth, J. S. S.: The results of testicular transplantation in brown Leghorn hens. *Proc. Roy. Soc. B.*, **106**, 1930.
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21. Greenwood, A. W., Dodds, E. C., Blyth, J. S. S., and Gallemore, E. G.: Observations on the assay of the comb growth promoting hormone. *Biochem. J.* (In the press.)
22. Lambie, C. G., and Wiesner, B. P.: On the relation between the hormone of the anterior lobe of the pituitary and clinical syndromes. *Edinb. Med. J.*, 1931.
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25. ——— ———: The effect of destruction of the spermatogenic tissue by X-rays upon certain secondary sex characters of the cock. *Quart. Rev. Exp. Phys.*, **21**, 2.
26. Mirskaia, L., and Wiesner, B. P.: Occurrence and mechanism of prepubertal mucification. *Proc. 2nd Inter. Cong. for Sex Research*, 1930.
27. Robson, J. M.: Mucification in the mature mouse caused by oestrin. *Proc. Phys. Soc.*, Nov. 15, 1930.
28. ———: The control of the pregnancy changes in the uterus of the rabbit. *Ibid.*, July 4, 1931.
29. Robson, J. M. and Illingworth, R. E.: Pregnancy changes in the rabbit's uterus and their relation to endocrine activity. *Quart. J. Exp. Phys.*, **21**, 1, 1931.
30. Smith, A. D. B.: The genetical improvement of dairy cattle in the tropics. *Proc. Inter. Dairy Cong.*, Copenhagen, 1931.
31. ———: Mendelism and farm livestock. *Eugen. Rev.*, **23**, 1.
32. Smith, A. D. B., and Robinson, O. J.: The inheritance of milk yield. *Proc. Inter. Dairy Cong.*, Copenhagen, 1931.
33. ——— ———: The average ages of cows and bulls in six breeds of cattle. *J. Agric. Sci.*, **21**, 1.
34. Wiesner, B. P., and Marshall, P. G.: The gonadotropic hormones (9-factors). I. The preparation and properties of extracts of anterior lobe, placenta and pregnancy urine. *Quart. J. Exp. Phys.*, **21**, 2, 1931.
35. Gutowska, M. S.: Effects of prolonged oral administration of large doses of pituitary anterior lobe to laying hens. *Ibid.*, **21**, 3, 1931.

PAPERS.

36. Pickard, J. N. A possible case of somatic segregation in the rabbit *J. Hered.*, **20**, 10.
37. ———: Further studies on the wool production of Angora rabbits. *Harper Adams J.*, **15**, 7.
38. ———: Die Vererbung von Haarbüscheln und Wollmenge bei Angora-Kaninchen. *Züchtungskunde*. **5**, 8, 1930.
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36. (CROP AND) ANIMAL HUSBANDRY DIVISION, MINISTRY OF AGRICULTURE FOR NORTHERN IRELAND.

Young beef.—During the past four years a herd of cross-bred Galloway cows, divided into two groups and sired by a pedigree beef Shorthorn bull, has been used to provide calves for experimental work in the production of young beef. Some groups of calves have been disposed of fat in June at the age of 14 months, some fat in December at 18 months, others as very forward stores at 9 months old, and the remainder fat from the grass at 16 months without any indoor feeding period. Various systems of rearing and feeding have therefore been tried, and an account of this work, giving a description of the systems, the live weight increases of the calves for the various periods of their lives, and the cost of production in each case, has been prepared and will shortly be published.

Statistical analysis.

Chicken rearing experiments.—The individual live weights of the birds at the time of separation of the sexes in 1929 and 1930 chicken rearing experiments (over 1,500 chickens being involved each year) were examined statistically with a view to determining the size of the errors to be expected in such experiments and the numbers of birds required to give significant demonstration of given differences between groups (1).

Title of paper issued during the year.

1. Hale, R. W.: Experimental errors in chicken rearing experiments. *J. Agric. Sci.*, **21**, 4, 1931.

H.

DAIRYING.

37. NATIONAL INSTITUTE FOR RESEARCH IN DAIRYING.

HUSBANDRY.

Inheritance of milk and butter fat.—During the last ten years the Institute has been building up a home-bred dairy herd of Shorthorns and Guernseys, and, in addition to providing milk and cows for experimental work, has given special attention to the collection of information on the inheritance of milk and butter fat. The herd of Shorthorns now consists of over 100 females of all ages and contains three generations in milk of the progeny of a number of foundation cows. Records are kept of (*a*) the milk yield, (*b*) the percentage of butter fat, (*c*) the calculated percentage of solids-not-fat, (*d*) the breeding history, (*e*) live weight and photographs, and (*f*) the quantities of foods given (except pasture and water). In a paper published in 1920 (" Breeding dairy cattle for milk production," *Journal of the Ministry of Agriculture*, Vol. 27), Mackintosh emphasized the importance of the use of sires of proved merit as judged by progeny records, and in the Institute herd one pedigree dairy Shorthorn bull has been used for eight years ; the records of his progeny are now accumulating in sufficient number to provide valuable material for inheritance studies and also for the calculation and checking of different methods of stating a " bull index " for milk and fat production. In addition to a large number of dam-daughter pairs, the herd contains 13 pairs of full sisters, all the progeny of the bull referred to. The information already collected has provided a basis for a butter fat scheme, and a register of merit for bulls adopted by the Dairy Shorthorn Association.

Investigation into the inheritance of dairy qualities and the accumulation of data under known conditions is naturally a long-distance project, and the management of the herd will be continued generally on the same lines with a view to the collection of the necessary information over a further period of years.

The rate of growth of young dairy stock.—During the last ten years records of the size and weight of young dairy cattle have been collected from the Institute's herd. An analysis of this data has been completed and a paper has been published in the *Journal of Dairy Research* (1). The paper shows the average growth rates of Shorthorn dairy cattle from birth to five years of age. Growth is shown in live weight and in three body measurements, height at withers, depth of chest and length of body. The two chief objects of the work are to provide a standard whereby stockraisers may judge the progress of their cattle and to lay down standards of growth for cattle of various ages for comparative use in experimental work. In some experiments it will now be unnecessary to use control animals, and the standards make possible a clearer interpretation of the results of experiments on the feeding of young dairy stock.

Calf rearing.—During recent years numerous experiments have been carried out on this subject in the Institute's herd. The main subject studied has been that of rearing calves on the minimum quantity of whole milk, so that calf rearing might be practised with economy and success on dairy farms where it is desired to sell the maximum quantity of whole milk. It has been found that for the purpose of maintaining the herd, heifer calves can be reared on 30-40 gallons of whole milk distributed over the first eight weeks and supplemented by suitably balanced cake and meal mixtures; further, the labour of feeding is greatly simplified by giving these foods in the dry condition rather than as gruels. A full report has been published (2).

Dried separated milk for calf feeding.—Small scale experiments to test the value of dried separated milk as a substitute for whole milk in the ration of young calves have been continued. The results obtained indicate that whole milk should be given for the first two weeks; when reconstituted dried separated milk was given during the second week the health of the calves suffered and very slight live weight increases were made. Calves reared on whole milk only for two weeks and on a diminishing allowance, supplemented by reconstituted dried separated milk for the next five weeks, made good progress. The milk powder was reconstituted by mixing 1 lb. with 1 gallon warm water and adding 1 oz. cod liver oil. The total allowance per head was 20 gallons whole milk and 25 lb. dried separated milk and a live weight increase of 1·04 lb. per head daily was obtained. A similar group of calves which received a total of 40 gallons whole milk during the same period gave a live weight increase of 1·21 lb. per head daily. From the fourth week onwards the milk allowance was supplemented by hay and a dry concentrate mixture. Additional experiments on the use of dried separated milk and other similar foods are in progress.

Causes of removal of cows from dairy herds.—This investigation was commenced in October 1929, and the methods of collecting and analysing the information have been settled in close co-operation with Dr. Sanders of the School of Agriculture, Cambridge.

During the year 1929–30 the Milk Recording Societies of Berkshire, Dorset and Hampshire co-operated with this department on a voluntary basis; the information obtained has been classified and studied, and interim reports have been sent to each Society and published in the respective Year Books for 1930–31 (3). For the year 1930–31 the Ministry of Agriculture made a grant to the Institute for this enquiry, and this assistance has made it possible to enlist the co-operation of three additional Milk Recording Societies, viz. Oxfordshire, Bucks and Northants. The analysis of the data collected during the milk recording year October 1st 1930 to October 1st 1931 is now proceeding, and there is evidence that the enquiry will provide most useful information on many points of practical interest to dairy farmers as well as indicate the incidence of the chief causes of removal of cows from dairy herds in the group of counties mentioned.

Milking machinery.

Testing.—During the year one milking machine has been installed and put into practical use for a test under the auspices of the Machinery Testing Committee of the Ministry of Agriculture. Another machine was also placed on test for a period to assist the Royal Agricultural Society in deciding upon an award made at the 1931 show.

Apparatus for measuring the speed at which the milk is drawn by milking machines.—In tests of milking machines conducted at this Institute the need for more complete and accurate information regarding the speed of milking has often been noted, and several enquiries indicated that a suitable apparatus could only be obtained at a relatively high cost. Recently, however, a simple and comparatively cheap apparatus has been obtained and a method of operation evolved which enables accurate determinations of the speed of milking to be made. Curves can now be prepared showing the rate at which milk is drawn from the udder throughout the period of milking, and this information is of value, not only as a means of comparing the efficiency of milking machines, but also for studies concerning milk secretion and yields.

HUSBANDRY AND CHEMISTRY.

A study of typical English milk.—A study of milk as produced under typical south of England conditions was begun in October 1928 and has been continued for three years. Ten dairy Shorthorn cows were selected from the Institute's herd and these cows have been fed during the winter on a ration of meadow hay, with kale, cabbage and mangels according to season, and a simple concentrate mixture of dried brewers' grains, maize germ meal and soya bean meal; during summer the main food has been pasture, supplemented when necessary by green forage crops and a concentrate mixture of dried grains and maize germ meal.

During the lactation periods of the cows, commencing with 1928–29, the milk of each cow was weighed and sampled and the percentage of butter-fat determined at each milking. The information thus obtained provided valuable information on the normal day-to-day variation in the yield of milk and butter-fat and has been reported on (4). It has also provided a basis for comparing the reliability of different methods for finding out the average percentage of fat in the milk of a complete lactation period; the information thus gained has proved of great value in devising a butter-fat testing scheme which can be worked in conjunction with the Milk Recording Scheme of the Ministry of Agriculture and Fisheries. (See *National*

Institute for Research in Dairying, Annual Report, 1929, p. 48 and 1930, p. 46.)

Throughout the three-year period composite milk samples from this group of cows have been made up each evening and morning and the percentages of fat and solids-not-fat ascertained. The hours of milking gave a night interval of approximately 15 hours and a day interval of 9 hours. A study of these results showed that during the spring and summer months the mixed morning's milk of this typical herd frequently fell below the presumptive standard of 3 per cent. The percentage of solids-not-fat was always above the presumptive standard of 8·5 per cent. except for a few instances in 1930. The freezing point of weekly morning samples was also determined for the greater part of the three-year period.

A more detailed chemical study was carried out on a composite sample of morning's milk once a week; determinations made of the total ash, the calcium and phosphorous content, the titratable acidity and the formol titration showed that the values remained on the whole very constant throughout the three years, whereas the values for total and casein nitrogen showed rather wide variations. The most striking variation was found in the time of the coagulation of the milk by rennet; this became very much slower in the winter months. A complete report on the three years' work is in preparation for publication in the *Journal of Dairy Research.*

The percentage of total solids in the samples of typical milk was determined by evaporation and also by calculation from the percentage of fat and the specific gravity (a method often used in dairy practice), and a comparison of the results showed that the value obtained by calculation was subject to a considerable seasonal variation, being higher in winter and lower in summer. This finding and its bearing on methods of analysis was the subject of a paper read at the 1931 summer meeting of the Agricultural Education Association (5).

A milk taint reported to be caused by molassed beet pulp.—Experiments on this subject have been carried out during the last two winters in conjunction with other centres, on lines agreed on at a conference convened by the Ministry of Agriculture.

During the winter of 1930–31 a group of cows received 9 lb. molassed beet pulp daily at various intervals before milking, and samples of the milk were compared with those from a control group of cows receiving exactly the same ration but excluding the pulp. No instance of tainted milk occurred throughout the experiments.

The chemical work of the winter of 1930–31 has been developed and special attention has been paid to the composition of the volatile base nitrogen of the non-protein fraction of the milk.

The volatile base nitrogen of normal milk from cows not receiving molassed beet pulp consisted of ammonia, but as soon as molassed beet pulp was fed the ammonia was replaced to the extent of as much as 40 per cent. by other volatile bases (trimethylamine), which did not give a colour with Nessler's reagent. As soon as the feeding of the molassed pulp was discontinued, the volatile bases gradually returned to 100 per cent. ammonia. The feeding of an ounce of betaine per day had the same effect. Milking at two hour intervals after feeding the pulp generally showed replacement of the ammonia by trimethylamine, which reached a maximum at four hours after feeding, after which time the amount of replacement decreased.

CHEMISTRY.

The solids-not-fat content of milk.—During recent years it has been shown that the percentage of solids-not-fat in the milk produced by a single cow and by a herd of cows may fall frequently and appreciably below the presumptive standard of 8·5 per cent. The causes contributing to this result are not known, nor can any suggestions be made as to how the percentage may be increased, but the problem is being studied from several different points of view.

By arrangement with the Advisory Chemist for the Reading Province samples are being taken at regular intervals from a herd in Hampshire and another in Berkshire where the milk is known to be low in solids-not-fat, and the conditions of production are being carefully studied. At the Hampshire farm changes were made in the ration during the winter of 1930–31 and again during the present winter, and a report on the results obtained will be forwarded to the Ministry in due course.

The method which has been perfected by Dr. W. L. Davies for the quick determination of chlorides in milk has been used throughout the winter season for the determination of chlorides in the milk low in solids-not-fat. It was found that the chloride content was high, thus pointing to lactose being the low constituent. The milk of individual cows also gave a variation in the chloride content which was accompanied by an inverse variation in the solids-not-fat; this was accompanied by low lactose, the protein content of the samples investigated being normal.

The rise in chlorides as the lactose falls maintains the osmotic pressure of the milk, and thus its freezing point, which is an index of the osmotic pressure, remains constant.

Butter.—The butter made from the Institute's "type" milk has provided material for Professor T. P. Hilditch and J. J. Sleightholme to carry out their work on the glyceride structure of butter fats (6).

Dr. W. L. Davies has also shown that the iodine values of butter fat prepared during the winter period showed a progressive decrease from the time the cows were brought in at night until the end of the stall feeding season. As soon as the cows went out to grass a sharp rise occurred, and the original maximal values for summer butter-fat were rapidly attained.

Cheese.—A further paper by G. M. Moir has been published (7). Moir has also published four papers on the determination of the milk proteins (8) ; these give the results of part of his work during the tenure of the Pedler research scholarship. Another paper by the same author on the use of the quinhydrone electrode has been published (9).

Nutritional value of raw and heated milk.—The possibility of a change in the nutritional value of milk when heated has long been obvious, but it has been very difficult to present concrete facts bearing out such a suggestion.

Laboratory work on observations of physical and chemical properties of milk which has been heated to varying temperatures (from 120° to 210° F.) for a known period of time gave certain proof that definite and demonstrable changes were brought about in the chemical composition of milk by the application of heat well below a temperature of 145° F. These changes, although chemically significant, were not large and the effect upon the nutritional value was not known.

E. C. V. Mattick and J. Golding have published (10) the results of an experiment in which rats were given milk which was either raw, "fresh" sterilised (heated once while fresh to 210°–212° F. for half-an-hour) or "kept" sterilised (in which some of the original milk was kept for 24 hours in a cool place both before and after having been heated for half-an-hour at 210°–212° F.). Each group of rats was given milk in excess of its daily requirements, and the only other food supplied was a known weight of "damper" made only from English flour and water and baked hard. The results indicated that this heat treatment of the milk had seriously affected its nutritive value. No second generation was raised from the rats fed on the milk which had been kept before and after heating while a second, but no third, generation was raised from those receiving "fresh" sterilised milk. The group of rats fed on raw milk continued to breed and lactate through several generations, a fifth having now been raised.

A second experiment on similar lines has definitely confirmed these earlier results. No second generation of rats were even produced by the group which was receiving milk which had been heated to 210°–212° F. for half-an-hour, while the animals themselves became very poor in condition and remained undersized. In this second experiment a group of rats which were given milk previously heated to an intermediate temperature of 145°–150° F. for half-an-hour was substituted for the group which received "kept" sterilised in the first experiment. The effect of this treatment upon the nutritional value of the milk has not yet been demonstrated by this experiment, but the results are suggestive and the experiments are still in progress.

Results of a further development of this work are contained in a paper read at the World's Dairy Congress in July. They have also been incorporated into lectures given before the Royal Society of Public Health and the Farmers' Club (11, 12).

It must be remembered that these experiments were designed to detect any gross alterations in the nutritive value of the milk which might be shown by lack of growth, condition or failure of reproduction or some other unmistakable signs of malnutrition. If such signs become well defined, it is hoped to carry out more detailed investigations as to the nature of the particular nutritional factors which may have been destroyed by the application of heat. The experiments will not indicate the effect, if any, on vitamin C, as rats thrive without this vitamin in their food.

The positive nutritional value of raw milk is demonstrated by the production of several generations of rats on such a simple diet.

The nutritional value of milk as shown by pig feeding experiments.—Pig feeding experiments by Golding and Blissett (13) have also demonstrated the value of even such small quantities of milk as half a pint of full cream milk per pig per day. It is significant that, of the 14 experiments conducted in this series with different foods and at different seasons of the year, the lots which received half a pint of milk instead of 2 oz. of meal always gained more weight than the pigs on meal alone, the gains being greater in the winter months.

The vitamin requirements of pigs.—In continuation of the work by Blissett and Golding on the inadequacy of white wheat flour and fish meal for prolonged growth of pigs (14), young growing pigs were fed on a diet which was rigidly deficient in vitamin B (complex) and also in vitamin C. The diet was composed of purified casein, polished rice, filter paper pulp, minerals and cod liver oil. The results showed that the pig is dependent for growth on vitamin B_1 and B_2. The requirements of the pig for vitamin C in the diet on the other hand are apparently negligible.

A preliminary paper (15) on this subject has been read at Oxford before the Biochemical Society, and a further paper will be published shortly in collaboration with Prof. H. H. Woollard of St. Bartholomew's Hospital.

Work on refection.—It has recently been shown by Prof. Fridericia of the University of Copenhagen that, under certain conditions, rats may thrive for indefinite periods of time on diets devoid of the B group of vitamins. This phenomenon, which has been attributed to an endogenous bacterial synthesis of the vitamin B (complex) has been termed " refection " by Fridericia. It is also well known that ruminants require very little, if any, exogenous vitamin B. Sir A. Theiler and his collaborators, in 1915, advanced the hypothesis that vitamin B is formed in the rumen by bacterial synthesis. These problems are now being investigated in collaboration with the Bacteriological Department.

A method for the estimation of starch in the faeces of rats used in these experiments has been worked out by Dr. W. L. Davies and a large number of analyses of faeces of rats under experiment has been undertaken.

Other rat feeding work on vitamin B has been done, and assays of the potency of samples of dried yeasts, etc., required as reference materials for further experiments have been conducted.

Disposal of by-products.—With the financial assistance of Lord Iveagh and a leading dairy company, this work has been further advanced and a patent (16) has been accepted. This embodied the improvements which have resulted from years of work which, with the assistance of the engineering department, has now been completed.

The final result is a simple device, which can be fitted to any roller drier, and provides a means of concentrating whey before evaporation on the rolls. The capital cost is not great. Half as much whey again can be dried as on the rolls alone, and that without extra cost. It is also suitable for milk or separated milk. This apparatus enables a dairy to deal with 500 gallons or more per day on its own premises.

The interest in, and uses for, these dried products are on the increase, and much co-operative work has been carried out to find new uses to which they can be put.

FAULTS OF DAIRY PRODUCE (EMPIRE MARKETING BOARD GRANT).

CHEMISTRY AND BACTERIOLOGY.

The investigations into faults of butter and other dairy produce commenced with the aid of a grant from the Empire Marketing Board have been continued, but the rate of progress has been retarded by the cessation of this grant during the year under review. In addition to the subjects mentioned below, Dr. W. L. Davies has assisted in other investigations.

Butter.—In collaboration with the staff of the Massey Agricultural College, New Zealand, experiments on ripened cream butter were undertaken by Dr. W. L. Davies. A consignment of experimental butter from ripened cream was examined after storage and transit. It was found that most of the butter samples had developed a fishy taint due to acidity in the butter. Determinations of the peroxide oxygen content of the samples showed that high acidity conditions in the butter caused high peroxide content; this was especially the case in its outer layers.

Metals.—Instances of the importance of traces of metallic contamination in the dairy industry continue to crop up.

The sources of entry of copper into milk from the corrosion of milk processing plants causing the development of oiliness in the milk have been investigated by W. L. Davies (17). The replacement of corroding parts has usually led to the disappearance of the taint. Various metals intended for use in plant equipment have been studied to determine their effect on milk and its products.

The presence of a trace of heavy metals in butter from sweet unpasteurised cream, caused partial to complete inactivation of lipase activity, varying with the nature of the metal. Copper was found to be most destructive. The degree of lipase inactivation was found to run parallel with the capacities of the metals, in their different concentrations, to catalyse fat oxidation.

Red or rusty spot in Cheddar and other hard cheese.—This investigation was originally made possible by the grant from the Empire Marketing Board, and although the grant ceased in March, 1931, the work has as far as possible been continued, albeit inadequately. In the course of the work it became clear that the state of our knowledge of the fundamental factors controlling cheese ripening is unsatisfactory and it became essential to plan a comprehensive piece of work designed to repair this deficiency.

The following is an outline of the major investigation which has been planned :—

(*a*) *Physical.*—Although body and texture are terms well understood by cheese makers, these terms do not permit of quantitative measurement. Methods will be worked out for the precise statement of practical terms in units of physical measurement.

(*b*) *Physico-chemical.*—Chemical reactions are largely controlled by such conditions as acidity (pH), oxidation-reduction potential (rH), and surface phenomena (adsorption-surface tension). The rôle of these in influencing the course of ripening will be studied.

(*c*) *Enzymic.*—Cheese ripening is primarily enzymic in nature, but the precise origin and nature of the enzymes involved are not yet known. Attempts will be made to differentiate and to measure the actions of rennin, pepsin and the enzymes of the lactic acid and miscellaneous flora in cheese.

(*d*) *Biological.*—The first investigations will endeavour to establish that part of the general flora which is essential for the products of cheese true to type, and incidentally to compare the effects of milk of different bacteriological quality on the final quality of the cheese. This last point is of great economic importance.

Following on the observations recorded in last year's report that some of the common milk bacteria growing with the red spot organism allowed the latter to form pigment with great rapidity, a cheesemaking experiment with milk specially produced under conditions of the strictest possible cleanliness on a badly infected farm was carried out.

Although red spot organisms were found in this milk, which was made up in a non-infected dairy, the ripe cheese was free from red spot, but a cheese made from the same milk at the farm was infected. Further a cheese made from the milk of the same farm taken in the ordinary way on the following day was badly infected.

By a series of eliminating experiments the sources of infection have been narrowed down to the milker and the cow, but so far teat siphon samples have failed to show the presence of the organism in the cow's udder. These experiments will be repeated at other seasons of the year. The details of the most recent experiments have been published (18).

BACTERIOLOGY

Fundamental investigation of Cheddar cheese ripening.

The types of lactic acid bacteria occurring most frequently in cheese have been determined, and some aspects of their chemical metabolism studied.

The results to date may be summarised as follows :—

(*a*) *Nitrogen metabolism.*—(i) The true lactic acid bacteria cannot utilise a mixture of purified amino acids and salts as a source of nitrogen.

(ii) The presence of growth factors does not enable these bacteria to assimilate inorganic nitrogen.

(iii) Different peptones vary in their effectiveness as a source of nitrogen. The lactobacilli seem to prefer the lower degradation products, whilst the streptococci grow fastest in those peptones rich in proteoses. This differentiation holds good in media containing peptic digests of casein.

(iv) The true lactic acid bacteria do not increase the formol titration of peptone sugar broth cultures in which the acid is not neutralised.

(*b*) *Characters.*—(v) The lactic acid bacteria appear to exert no metabiotic effect in sugar peptone broth cultures.

(vi) The reducing intensity is at a maximum in Cheddar cheese during the first week, and then rises to a fairly constant level. After about six weeks however a slight fall is detectable. These phases probably correspond to the growth of streptococci and later the lactobacilli (19).

Milk.

Thermophilic bacteria in raw milk.—It has been shown chiefly by American workers that thermophilic bacteria which may cause difficulty in controlling pasteurised milk occur in raw milk as it comes from the farm.

A study was therefore undertaken to determine as far as possible the relationship of the methods of production to the frequency of occurrence and the numbers of thermophiles present in the milk, and it was found that, of 67 samples of clean milk produced at the Institute's farm, two showed the presence of thermophiles.

When a local supply of ordinary milk was similarly tested on 63 occasions thermophiles were found in 44 cases. Moreover, of

17 samples of ordinary milk supplied to a London milk depot 15 showed thermophiles.

When clean milk was infected by contact with hay, straw, mangel, silage or fodder mixtures, thermophiles were found in ·10 cases out of 10 tests. The actual number present was in the great majority of cases very small.

A member of the staff, who had difficulty in isolating thermophiles from some samples which gave clear microscopical and other evidence of their presence, has found by the examination at frequent intervals of samples held at 62° C. that although after a short incubation time very large numbers of coccoid forms and bacilli were present neither could be recovered after holding for 24 hours. The work demonstrated that at about the sixth hour the numbers as shown by plating began to increase rapidly, and the increase continued to about the tenth hour. After this time a definite decrease set in and after about the thirteenth hour it was difficult to recover the organisms.

Incidentally during this work it was found that, if the vessels used had only been washed and not sterilised after previous use, thermophiles could often be found in milk which was apparently free from them when held in sterilised tubes. This is an interesting sidelight on a possible mode of infection in some types of pasteurising plant.

Media and technique of the plate count.—It has become increasingly evident that the media at present used for the examination of milk, and particularly of " pasteurised " milk, give figures which are too low.

The observations made in this laboratory and elsewhere, that in the first dilutions the number of colonies is proportionately greater than in the later ones, led to the addition of freshly boiled raw milk in various amounts to the plates. As stated in last year's report, this addition resulted in an increase in the number of colonies which could be counted.

It has also been shown that (as would be expected) incubation for an additional day (the standard time is 48 hours at 37° C.) resulted in an increase in the number of colonies counted and in the size of the colonies themselves.

These effects are also obtained in a more marked degree by the addition of milk. Those colonies which are invisible or impossible to differentiate in media containing no milk became easily countable.

This question of colony size is of great importance in the plate count method of estimating bacterial numbers, since counting is undoubtedly one of the greatest sources of error. In order to investigate the question of colony size and its relation to the composition of media, samples of commercial pasteurised, and of " clean " raw milk were plated by the same person using a standard technique on a standard agar (Ministry of Health) reinforced by the following additions: lactose, dextrose, galactose, galactose and dextrose, yeast extract, milk (raw) and milk (boiled).

Of the sugars, lactose gave the best results but the differences were in no way striking.

Yeast extract gave larger colonies, particularly of chromogenic types, and spore formers, but no significant increase in numbers.

Milk gave the best results, and boiled milk was as good as raw milk (it is of interest to note that clean milk after boiling showed no growth when plated as a control measure, except in one case where three colonies of a spore former appeared).

The superiority of milk as an addition to a medium over the other substances experimented with led naturally to the suggestion that milk powder might well be used because of its uniformity. Such a medium (Ayers and Mudge) was tried in the laboratory some years ago, but failed on account of the difficulty in counting due to undissolved or precipitated particles.

Recently also it has been found that a special grade of very soluble skim milk powder gave rise to heavy precipitation which precluded its use. It is possible that by varying the technique of making, such a milk powder medium could be obtained free from precipitate, or possibly a very dilute reconstituted skim milk might replace water or saline. Such a method would combine the advantages of a medium of nearly constant composition with freedom from undesirable precipitates in the agar. There would still remain the difficulty of filling out a nutritive fluid under aseptic conditions.

In view of the success attending the addition of milk to the ordinary medium immediately before pouring, and the fact that the opacity of the plate is not materially increased and no precipitates form, it appears that the use of milk deserves serious consideration. An objection to its general adoption would be variability in the composition of milk, but if always taken from a large bulk the variations would probably be very small.

The work that has been carried out has demonstrated quite clearly the difficulty of designing a medium which will suit all types of milk and the organisms found in them. For example, it has been pointed out that as a rule the addition of lactose did not materially alter the numbers of colonies that appeared, yet in one series of experiments on pasteurised milk it was observed that in some cases lactose added to the medium definitely decreased the count or failed to give a count at all. In other cases great increases were observed when lactose was added. It appears that if heat resistant streptococci are present lactose gives increased counts, but if thermophilic bacilli of some types are present they are suppressed by lactose.

Sterilised Milk. Carbolic taint.

The causative organism.—This has been shown to be an atypical member of the aerobic spore-forming group. Its relationship to other members of this group is now being studied.

In sterilised milk it forms phenols and ketones which cause the characteristic flavour.

Spore formation.—Spores are found in commercial bottles of sterilised milk, but in laboratory cultures they are rapidly lost and replaced by a stable vegetative form which has resisted attempts to cause it to revert to the spore form.

If however cultures containing spores are heated at 100° C. for 1 hour in broth or 2½ hours in milk, sporulation will take place and continue indefinitely in sub-cultures so long as these are heated.

The function of the heat appears to be the destruction of a factor inhibiting germination of the spores. This factor is associated with the vegetative forms or with a heat labile product of their growth.

Instability of spore form.—The organism occurs in two distinct forms: (*a*) a sporogenous, which is unstable, and (*b*) an asporogenous, which is stable. Although their biochemical and cultural reactions are similar, the two forms are distinguished by colony form and morphology. These characters are strongly suggestive of the "rough" and "smooth" forms described for other organisms.

Segregation into the two forms takes place during the sporulation process, and detailed studies of the morphology of spore formation suggest that some light may be shed on the mechanism of variation in the aerobic spore-forming group.

The conditions of commercial sterilisation have been shown to provide the organisms with all the factors necessary for the proliferation of the spore form, since the spores are released from the inhibitory factor by the heating process and are thus able to multiply in the bottles of milk. Bottles which have contained tainted milk will therefore contain spores. This fact led to the practice of sterilising the empty bottles as the chief control measure. Sporulation takes place at all temperatures from 5° C.-30° C. and is at the optimum at 22° C. The seasonal appearance of outbreaks of the trouble is due, it seems, to the influence of temperature on the rate of spore formation (20).

Resistance of spores.

(*a*) *Heat treatment.*—A study is in progress of the resistance of the spores to heat and other destructive agents, and it has been found that those in homogenised milk are very resistant. For example, they resisted 100° C. for 2½ hours but not for 3 hours. Exposure to 105° C. for 30 minutes had no effect, and their growth was only delayed by prolonging the time to 40 mins. Even at 110° C. delayed growth still occurred after 40 mins. exposure to this temperature, but 20 mins. at 120° C. has always been effective for complete sterilisation.

(*b*) *Chemical treatment.*—Somewhat drastic chemical treatment is necessary to destroy the spores.

4 per cent. NaOH at 145° F. ..	Spores resist for at least 15 minutes.
4 per cent. NaOH at 170° F. ..	Spores from milk killed in 15 minutes. Spores from agar cultures killed in 5 minutes.
3 per cent. NaOH at 145° F. ..	Spores from agar not destroyed in 30 minutes.
3 per cent NaOH at 170° F. ..	Spores from agar not destroyed in 20 minutes.

A commercial disinfectant (0·047 per cent. Cl) was not effective in 5¾ hours at room temperature. Tests are in progress to find the influence of the addition of NaCl to the NaOH solutions. Spores from infected milk were usually more resistant than those from agar slopes. (Although it is difficult to deal with spores in bottles of milk, treatment can readily be applied to empty bottles.) Where the advice to steam bottles for 3 hours at 100° C. has been closely followed, the results, in the case of epidemics of the taint, have been satisfactory.

Where steam under pressure can be applied the time of exposure can be considerably shortened.

Factory investigations.—With the co-operation of several factories it has been possible to study the incidence and the probability of the propagation of spores in the factory.

The milk.—Although it has been possible to study comparatively few supplies of milk which arrive at infected factories direct from the farm, it can be stated that so far the organism has never been found to be present in samples taken direct from the churn: e.g., of 30 samples taken from churns, and 10 samples from the tipping tank, only one (from the tipping tank) was found to be infected.

On the other hand, in a factory which was badly infected last year and was suffering to some extent this year, and which uses bulk milk from a wholesale depot, of 208 samples taken from churns, 11 were found to be infected.

The plant.—Tests of samples taken from the plant at various factories show that the bulk of the contamination is introduced at the factory, e.g., of 208 samples direct from churns, 11 were infected, but of 87 taken on the same days from the plant 18 were infected.

The homogeniser.—Tests with a small homogeniser showed that the greater part of infection of spores was fairly easily washed out. Small numbers were however retained in the gland packing and could be recovered after a fortnight during which the machine had been washed and steamed daily. It seems that frequent renewal of the packing is necessary to avoid contamination of milk by the homogeniser.

Coolers.—Coolers are often fixed and therefore difficult to clean. They are also subject to frequent contamination, and this may account for the appearance of occasional tainted samples in a factory, in the dust of which spores have been detected.

Bottles and bottle washing plant.—This has been found to be by far the greatest source of infection during seasonal outbreaks of the taint, and it is at these points that the remedial measures can be best applied (21, 22).

Cheese.

Quinhydrone electrode determination of pH.—Numerous samples of cheese have been examined by this method with satisfactory results. The method is very useful for the Cheddar type of cheese, since it does not require the addition of water for emulsification, as is the case with the hydrogen electrode. Indicators are not satisfactory owing to the difficulty caused by the presence of fat, emulsification and protein error (23).

"*Stinker cheese*" (*Cheddar*).—A number of samples of "stinker cheese," rennet and starter have been examined. Anaerobic putrefactive spore formers have been recovered from all the cheese and some rennet samples, but none has so far been found in the starters examined. Attempts to recover the organism which had been added in quantity to starter failed after the second sub-culture of the starter, which was managed in the ordinary way.

Moreover, attempts to make "stinker cheese" have failed in spite of heavy additions of anaerobic putrefactive bacteria which had given the typical smell and reactions in milk under favourable conditions of reaction. It appears that something more than the mere presence of the organism is necessary for the production of "stinker cheese."

Stilton cheese.—In order to test the influence of changes of acidity on the development of the mould of "Stilton cheese," analyses were made at different stages of ripening. Six batches of milk were made into cheese (each of 6 gallons) and allowed to ripen in the ordinary way.

Batches I, II and IV were made from clean milk and contained 6 cheese each, which were tested at monthly intervals.

Batches III, V and VI were made from ordinary milk and each consisted of 15 to 18 cheese. These were tested daily at first, and later at weekly intervals.

One whole cheese was used for each set of analyses.

(*a*) *The pressure expressate* (by Barthel's method).—(i) Titratable acidity, using NaOH, (ii) pH, hydrogen electrode, (iii) soluble nitrogen, Kjeldahl, (iv) amino-nitrogen, formol titration method, (v) NH_3 nitrogen, distillations with $MgCO_3$.

(*b*) *The solid cheese.*—(i) Moisture, (ii) total nitrogen, (iii) fat (Rose Gottlieb), (iv) volatile acidity.

The nitrogen determinations were used as a guide to the degree of ripening, and the results showed that, in spite of the fact that a separate cheese was used for each set of determinations, the course of ripening was remarkably constant in the cheese of each batch.

It was found that after the initial rapid rise in acidity, the figures for titratable acidity and pH were practically constant, and there was no indication of a relationship between these and the " blueing " of the cheese. It appeared however that there was a close relationship between the volatile acidity and " blueing," since although the figures for each batch varied somewhat, successfully " blued " cheese always showed a low volatile acidity. The steadiness of the nitrogen figures showed that the main course of ripening had been the same for all members of each batch. It is probable that the mould growth (blueing) was responsible for the removal of volatile acids (or their salts) which provided an easily assimilable source of carbon (24).

Starters. Slow working.—It is known that different strains of lactic acid streptococci (*S. lactis* and *S. cremoris*) show widely different rates of acid formation in milk, and it has been noticed that the colonies of the organisms could be classified into " rough " and " smooth " types.

An attempt was therefore made to correlate colony type with acid production. The work is incomplete but the results to date are suggestive. A number of starters were received from farms where " slow working " was found. These were (*a*) plated on appropriate media, from which pure cultures were obtained, grown in the milk of the Institute farm, and returned to the sender—they were then found to behave normally ; and (*b*) grown in the milk of the farm from which they came and returned to the sender—again normal working followed. No explanation of this phenomenon is offered at the present time. Further work is obviously necessary.

Butter.

Numerous samples of butter were plated on media of low pH (3·5) in order to test for the presence of yeasts and moulds.

Experiments with different media and methods of sampling were also carried out to determine the general flora and yeasts and moulds. The majority of the samples came from New Zealand and were examined at the request of the New Zealand officials in London (25).

Bovine tuberculosis.

Experiments designed to establish the viability of *B. tuberculosis* on grass in pastures and in soil, dung and soil and dung mixtures have been carried out during the year, and an improved technique for the work has been devised. Naturally-infected material has been used throughout and the weight of infection is known.

The results to date indicate that the organism survives longer than had previously been thought to be the case. It is probable that the improved technique has materially assisted in demonstrating this point.

Examination of published methods involving the recovery of the bacillus by cultural methods from infected material has shown them to be inapplicable to milk.

This investigation has been made possible by the award of the Lawrence Research Fellowship to Col. E. C. G. Maddock and by a grant for expenses from the Royal Society.

PHYSIOLOGY.

External conditions as affecting milk secretion.—A study has commenced of the possible influence of external conditions such as temperature and sunlight on the yield and composition of milk. It is hoped that this work may give results of definite physiological, if not directly practical value.

Nutritional requirements for lactation.—Work is in progress to determine the nutritional requirements for lactation, based on a study of cases of failures in lactation of rats. Numerous workers have recorded the occurrence of lactational failure in rats receiving diets which are apparently complete. A note describing earlier work has been published by S. K. Kon, *The Lancet*, April 4th, 1931, p. 778. This work is being carried out in collaboration with the Chemical Department, and in association with Dr. V. Reader of the University of Oxford.

Studies of blood composition in relation to milk secretion.—A study is being made of the effect on the composition of milk of variations in the composition of the blood, with a view to elucidating the mode of formation of milk in the udder cells. Some blood samples from cows in a herd giving milk low in solids-not-fat have also been examined in connection with the work of the sub-committee appointed by the Reading Provincial Agricultural Conference. The work on blood composition is yielding results of definite value.

Titles of papers issued during the year.

1. BARTLETT, S., and JAMESON, J. L.: Normal growth of dairy cattle. *J. Dairy Res.* **3**, 2.
2. MACKINTOSH, J.: Calf rearing on milk selling farms. *J. Brit. Dairy Farmers' Assoc.* **43**, 1931.
3. DAIRY HUSBANDRY DEPARTMENT: Investigation into the causes of removal of cows from dairy herds. Milk recording year, 1929-30. *Berks Milk Recording Soc. Yr. Bk.*, 1930-31.
4. BARTLETT, S.: Normal day to day variability of milk and fat of individual cows. *J. Agric. Sci.* **19**, **3**.
5. BARTLETT, S., GOLDING, J. and WAGSTAFF, A.: The effect of season on the reliability of the percentage of solids-not-fat in milk as calculated by formulae. *Agric. Prog.*, 1932.
6. HILDITCH, T. P., and SLEIGHTHOLME, J. J.: The glyceride structure of butter fats. *Biochem. J.* **25**, 2.

7. Moir, G. M.: Pasteurised milk for Cheddar-cheese making. II. The mineral content of Cheddar cheese. *J. of Dairy Res.* **2**, 2.
8. ————: Determination of the milk proteins. *Analyst*, Jan., Feb., Mar. and Apr., 1931.
9. ————: The use of the quinhydrone electrode. *Ibid.*, July, 1931.
10. Mattick, E. C. V., and Golding, J.: Relative value of raw and heated milk in nutrition. *Lancet*, Mar. 21st, 1931, 662.
11. Stenhouse Williams, R., and Mattick, E. C. V.: The importance of a complete study of the nutritional value of milk. *J. State Medicine.* **39**, 3, 1931.
12. Stenhouse Williams, R.: Our milk supply. *J. Farmers Club*, May, 1931.
13. Golding, J., and Blissett, A.: Results obtained by feeding small quantities of cow's milk to porkers. *Pig Breeders Ann.*, 1931-32.
14. Blissett, A. H., and Golding, J.: On the inadequacy of white wheat flour and fish meal for prolonged growth of pigs and its amelioration with yeast or stout. *Biochem. J.* **24**, 1, 349, 1931.
15. Foot, A. S., Golding, J., and Kon, S. K.: A note on the requirements of the pig for the vitamin B complex. *J. Soc. Chem. Ind.*, 422, May, 1931.
16. British Patent No. 360,038: Improvements in or relating to evaporating apparatus.
17. Davies, W. L.: Milk and metals. *Agric. Prog.* **7**, 1930.
18. Mattick, A. T. R., Davis, J. G., and Dearden, D. V.: Rusty spot in Cheddar and other cheese. III. A. Further factors controlling pigmentation. B. The application of the results of laboratory investigation to cheese making. *J. Dairy Res.* **2**, 2, 190, 1931.
19. Davis, J. G.: Studies in Cheddar cheese. I. Oxidation reduction potentials of ripening Cheddar cheese. *Ibid.*, **3**, 2. (In the press.)
20. Christian, M. I.: A contribution to the bacteriology of commercial sterilised milk. II. The "coconut" or "carbolic" taint. *Ibid.*, **3**, 1, 113, 1931.
21. Hiscox, E. R.: Notes on carbolic taint in sterilised milk. *Dairyman*, Dec., 1930.
22. ————: A contribution to the bacteriology of commercial sterilised milk. III. The basis of control. *J. Dairy Res.* **3**, 1, 130, 1931.
23. Davis, J. G.: A simple inexpensive quinhydrone cell for rapid work. *Analyst.* **56**, 664, 449, 1931.
24. Hiscox, E. R.: The volatile acidity of Stilton cheese. *Orla-Jensen Festskrift.* 75, Copenhagen, 1931.
25. Davis, J. G.: Standardisation of media in the acid ranges with special reference to the use of citric acid and buffer mixtures for yeast and mould media. *J. Dairy Res.* **3**, 1, 133, 1931.

38. HANNAH DAIRY RESEARCH INSTITUTE.

Tuberculosis in dairy cows.—A full report, containing the survey of the extent and causes of re-infection in tuberculin-tested (licensed) herds referred to in the last annual report, has now been published by the Institute (1). The recommendations contained in the report have already proved of considerable value to owners of tuberculin-tested herds by indicating the more important sources through which their herds may become infected.

Further progress has been made in the experimental scheme of eradication undertaken by the Institute (3). Seventeen of the thirty-two farms comprising the area have already been cleared of infection, while the diminution in the number of reactors in the remaining herds is marked.

An investigation into the infection of the Scottish milk supply, which is being carried out in conjunction with the Department of Health for Scotland, and with the Health Authorities of Edinburgh, Glasgow, Dundee and Aberdeen, is now well under way, and it is anticipated that a full report of the work will be published during the coming year. The investigation aims at determining the relative tuberculous infection of the milk supply in different localities, and of milks treated by different methods—raw, graded, and pasteurised.

Nutrition.—In connection with the work carried out on the protein requirements for milk production, a number of analyses has been made with the object of determining the exact amino-acid content of typical foodstuffs used in Great Britain. The next step, namely to investigate the relation of the amino-acid content of foods to their value for milk production, is now being taken.

Parallel studies are being carried out on the mechanism of digestion of the nitrogenous constituents of food in the rumen. In particular the effect of bacterial action on the protein and the non-protein nitrogen is being investigated, together with the gas production *in vitro* and *in vivo* as influenced by different foodstuffs.

Milk secretion.—Intensive work is being carried out on the biochemical aspects of milk secretion. Previous results obtained at the Institute had confirmed the very important function of the free amino-acids of the blood as precursors of milk protein. Further results have modified somewhat the previous theories of the utilisation of milk precursors by the mammary gland, and this aspect of the problem is now being studied by physico-chemical investigation of the actual mechanism of secretion.

"Constitution" in dairy cows.—The results of the first year's survey of the causes of loss in milking herds have now been published (4). This survey was carried out in collaboration with the Scottish Milk Records Association and a representative *ad hoc* committee. The results show that practically 50 per cent. of the cows drafted out from typical dairy herds are disposed of on account of disease, the major sources of loss being due to abortion, mastitis, and tuberculosis. 20 per cent. of the remaining disposals are sold for profit as surplus stock, while practically 17 per cent. are drafted out on account of poor milk yield.

These figures indicate the urgent need for further investigation, particularly with regard to the three diseases mentioned above.

Surplus milk and milk residues.—The issue of the detailed summary of the literature on the condensing and drying of milk and milk residues, referred to in the last annual report, has unfortunately been delayed, but it is anticipated that it will be published at an early date. It has been found necessary to extend the scope of the report to include the engineering, as well as the biochemical and bacteriological, aspects of the subject, and this supplementary work is being carried out at the Royal Technical College, Glasgow.

The preliminary experiments which have so far been carried out into the engineering and physical aspects of spray drying have indicated the need for a fuller exploration of the factors controlling the solubility of milk powders (9). Experiments have therefore been commenced during the year with this object in view, and already promising progress has been made.

Titles of papers issued during the year.

1. Fowler, A. B., and Wright, N. C.: Reactors in tuberculin-tested (licensed) herds. *Bull. No.* 2.
2. *The Hannah Dairy Research Institute. Its Origin and Work. Brochure.*
3. Jordan, L.: Eradication of bovine tuberculosis. *Rep. of Central Council of Milk Recording Soc. for year* 1930.
4. An inquiry into the length of life of dairy cattle: *Scott. Milk Records Assoc. Rep.*, 78, 1930. Interim Rep. of Special Committee.
5. Morris, S., Watson, A. McL., and Morris, N.: Metabolism studies in tetany. *Biochem. J.* **25**, 3, 786, 1931.
6. Fowler, A. B.: Renewal of old pasture. *Scott. J. Agric.* **14**, 4, 439, 1931.
7. Wright, N. C.: The Hannah Dairy Research Institute. *Ibid.*, **14**, 3, 233, 1931.
8. Allen, L. A.: The rôle of milk constituents in breadmaking. *J. Roy. Tech. Coll., Glasgow*, Jan., 1931.
9. Scott, A. W.: Small scale research on the spray drying of milk. *Ibid.*
10. Wright, N. C.: The Hannah Dairy Research Institute. *Ayrshire Cattle Soc. J.* **3**, 1, 5, 1931.

39. DAIRY BACTERIOLOGY DIVISION, MINISTRY OF AGRICULTURE, NORTHERN IRELAND.

Work in this Division has been mainly on the lines indicated in previous reports. The work in connection with the Sale of Milk Act, (N.I.) 1927 has increased considerably and advisory visits and laboratory routine occupy the major portion of the staff's time. A clean milk competition confined to licensed producers was conducted during the spring and summer months.

An investigation is in progress on the quality of ordinary milk for human consumption as sold in Northern Ireland.

Work in connection with the bacteriological control of creameries was continued. Special efforts are being made to standardise the work in the creameries engaged in the cream export trade. Experiments were carried out to ascertain the most suitable method of pasteurising cream for this trade, and valuable suggestions were made to the managers concerned. Arising out of this work it is hoped that definite recommendations can be made as to the most suitable methods to use for producing a high class cream.

Increased use has been made of the facilities at the disposal of farmers and veterinary surgeons for investigation of problems concerned with milk production. In this connection numerous samples have been examined ; these included milk taint troubles, suspected tubercular milk, cream and butter taints.

I.

AGRICULTURAL ECONOMICS.

40. AGRICULTURAL ECONOMICS RESEARCH INSTITUTE, OXFORD UNIVERSITY.

Progress in farming systems.— A few years ago it was decided to study notable achievements in farming practice representative of new ideas in farm management evoked by the changing economic conditions of the industry. With one exception, the earlier studies were confined to new methods in arable farming, the branch most seriously affected by the fall in prices, and the same course has been followed in the last year.

A notable enterprise in Wiltshire for the production of milk on a large scale, where new methods in arable farming are applied to the production of nearly all the foods, other than grass, required by the herd of 600 cows, was investigated, and a report thereon published (4).

Another report dealt with a large arable farm in Oxfordshire, where crop production without livestock is carried on largely by mechanised operations (3).

A third report deals with an interesting and successful venture in Hampshire, where intensive corn production is still being carried on profitably, notwithstanding the fall in prices (5).

Each of these investigations has been carried out by the Director.

The mechanisation of farming.—In collaboration with the Agricultural Engineering Institute, arrangements have been made for a study of certain farms which have been equipped to raise the efficiency of the agricultural labourer by the substitution of mechanical power for horse labour. Particular attention is being devoted to farms where tractor cultivation and the combine-harvester are in operation. Mr. M. Messer is engaged in this work.

Economic surveys.—Mr. R. N. Dixey has completed the analysis of data collected for a general farm management survey covering about 40,000 acres in South Oxfordshire. The survey is the repetition of one made by Mr. Dixey and Mr. A. Bridges in 1923. Some interesting changes in farming practice are disclosed, and two pronounced tendencies may be noted. The first is the attempt to substitute production of commodities less affected by the decline in prices, for example, grass-land and livestock, for ploughland and corn. The second is the attempt to accelerate the cash turnover, milk being substituted for beef, lamb for mutton, and pork for bacon pigs. Two other definite indications of change are of interest. One is the increase in the average size of farms, smallholdings being absorbed into larger units. The other is the decline in the amount of hired labour employed, due in part, no doubt, to the increased use of machinery, but mainly to the greater number of farmers' relatives working on the land to-day, compared with the more prosperous times of eight years ago. A report has been published (7).

A special farm management survey was carried out by the Deputy-Director, in collaboration with a former research scholar, Mr. A. Jones, Advisory Economist of the Midland Province, upon factors affecting beef production in the Midland grazing area. The tendency towards the production of finished cattle at an earlier age, to meet the housewife's needs for small joints, was noted, though the increase of the dining-out habit maintains the demand for mature cattle of high quality for hotels and restaurants. A report has been published (6).

The distribution of agricultural produce.—In continuation of the study of the marketing of dairy products, the investigation of the butter-making industry in West Cornwall has been completed. A further study of milk production under entirely different conditions in the Isle of Ely was begun, and the field work was carried through. With the examination of an area where domestic cheese manufacture is the important outlet for milk, which it is hoped to undertake in the coming year, the whole field of milk distribution and utilisation will have been covered by Mr. F. J. Prewett.

A report on the marketing of hops was prepared and published by Mr. D. Skilbeck (8).

Farming costs and financial records.—During the year much costing data has been received from certain of the provincial advisory centres where costing has been carried on for some years. Differences in method have made it impossible completely to co-ordinate the results, but the Institute is now in possession of cost summaries of crops and products throughout England, since the year 1927. Work on records collected by the Institute has been continued, and results of interest to farmers have been published from time to time by the Deputy-Director and Mr. J. R. Lee in *Occasional Notes* (19).

Agricultural economics within the Empire.—The survey of dairying conditions in Empire countries, to which reference was made last year, has been completed by Mr. J. P. Maxton, and a report is being prepared.

Agricultural atlas of England and Wales.—The revision of this atlas has been completed by Mr. M. Messer, and the maps are now being printed by the Ordnance Survey Department.

The agricultural depression.—Three years ago an enquiry was set on foot to determine the incidence of the agricultural depression which was then beginning to be felt. Results showed that it was confined almost entirely to the corn-growing districts. Since then the fall in prices has proceeded rapidly, and the enquiry was repeated during the latter months of the year by Mr. Messer to find out to what extent other districts were affected.

Prices and statistics.—Mr. K. A. H. Murray has continued his studies of price movements, particularly in relation to livestock (2).

Further progress has been made by Mr. Maxton with the guide to official agricultural statistics.

Rural migration.—Mr. E. Lorrain-Smith, a Ministry of Agriculture and Fisheries research scholar attached to the Institute, has completed his investigation of migratory movements amongst farmers, and has embodied the results in a thesis for the degree of B.Litt. Three principal areas of emigration were disclosed, namely, South-west Scotland, Lancashire and the West Midlands, and Cornwall, Devon and Somerset. The movement is always towards the eastern and south-eastern counties, and its extent and causes are discussed in Mr. Lorrain-Smith's thesis.

Titles of papers issued during the year.

(*a*) *BOOKS.*

1. Orwin, C. S.: *The future of farming.* Clarendon Press.
2. Murray, K. A. H.: *Factors affecting the prices of livestock in Great Britain.* Clarendon Press.

(*b*) *PAMPHLETS.*

3. Orwin, C. S.: *Progress in English farming systems. IV. Another departure in plough farming.* Clarendon Press.
4. ———: *Progress in English farming systems. V. A pioneer of progress in farm management.* Clarendon Press.
5. ———: *Progress in English farming systems. VI. High farming* Clarendon Press.
6. Bridges, A., and Jones, A.: *The Midlands grazing industry.* Clarendon Press.
7. Dixey, R. N.: *The farmer's business.* Clarendon Press.
8. Skilbeck, D.: *The marketing of farm produce. III. Hops.* Clarendon Press.

(*c*) *ARTICLES AND ADDRESSES.*

9. Orwin, C. S.: The agricultural problem. *Political Quart.*, Dec., 1930.
10. ———: Re-organising the parochial system. *Chichester Diocesan Gaz.*, Dec., 1930.
11. ———: More arable land goes down to grass. *Yorkshire Post Trade Rev.*, Jan. 8th, 1931.
12. ———: The problem of arable farming. *Oxfordshire F.U. Yr. Bk.*, 1931.
13. ———: Cutting the farmer's costs. *The Listener*, Aug. 12th, 1931.
14. ———: *George Baylis and the implications of his system of farming. Agric. Prog.*, **8**, 1931.
15. Bridges, A., and Watson, J. A. S.: The future of corn growing. *Scott. J. Agric.* **14**, 1, 9, 1931.
16. Murray, K. A. H.: A survey of the prices of pigs and feeding-stuffs in England and Wales during 1930. *Pig-Breed. Ann.*, 1931-32.
17. Prewett, F. J.: Recent developments in co-operation in the United States of America. *Yr. Bk. of Agric. Co-op.*, 1931.
18. Agricultural Economics Research Institute: Methods of research in agricultural economics. Paper read by C. S. Orwin. *Proc. Agric. Econ. Soc.*, 1930.

(*d*) *PERIODICAL.*

19. Occasional Notes. **1**, 12, 13, 14 and 15.

41. FARM ECONOMICS DEPARTMENT, DEPARTMENT OF AGRICULTURE FOR SCOTLAND.

The economic position of agriculture in Scotland.—The first report on the profitableness of certain groups of farms characteristic of the agriculture of important farming areas of Scotland was issued in June, 1931, and covers a period to Martinmas, 1929 (1). A further report for the farming year 1929–30 has been completed and is in the press. These reports are based upon financial records received by the Department from the Agricultural Economists at the three Scottish Agricultural Colleges. These records serve the double purpose of providing a basis for advisory services and also for the preparation of national statistics.

Distribution of farming systems in Scotland.—An account on a statistical basis of the distribution of farming systems in the eastern borders of Scotland was published as Part II of the first report referred to above. During the year the work of classification has been carried out for the greater part of the remainder of Scotland south of the Forth and Clyde.

Marketing of agricultural produce.—Investigations carried out under a grant from the Empire Marketing Board into the marketing of live stock and potatoes in Scotland have been completed, and the preparation of reports is in progress. An enquiry into the marketing of grain and grass seeds is now proceeding.

Physical conditions and farming practice.—An investigation undertaken by Miss E. Snodgrass, M.A., of the Department of Geography, the University of Edinburgh, in collaboration with the Department, into the connexions between physical and economic environment and farming practice over a considerable area of Scotland, was completed during the year. Miss Snodgrass was awarded the degree of Ph.D. of the University of Edinburgh for her thesis.

Miscellaneous.—Since the inception of farm economics investigations in the Department and in extension of the Departmental enquiries, the changes in the numbers and distribution of live stock in Scotland over a period of fifty years have been examined and their connexions with price movements traced (2). In papers by the Advisory Officer in Farm Economics to the Department, the place of the investigations in hand in a general scheme of economic enquiry and the principles underlying the technique adopted (3, 4, 5), the comparative value of such national studies in international statistics (6), and the application of the principles of specialisation and of large-scale industry to agriculture in Great Britain (7), have been discussed.

The general economic features of the pig industry in Scotland and its prospects of development have also been examined (8).

Titles of papers issued during the year.

1. DEPT. OF AGRICULTURE FOR SCOTLAND. The profitableness of farming in Scotland.
2. GREIG, Sir R. B., and KING, J. S.: Distribution of live stock in Scotland—50 years' changes. *Scott. J. Agric.* **12**, 3, 235, 1929.
3. KING, J. S.: A programme of research in agricultural economics. *J. Proc. Agric. Econ. Soc.* **1**, 3, Dec., 1930.
4. ———: Agricultural economics investigations in Scotland. *J. Farm Economics* (U.S.A.), Apr., 1930.
5. ———: The national value of farm accounting data. *Proc. Internat. Conf. Agric. Econ.*, Ithaca, New York, 1930.
6. ———: Farming costs and accounts. *Encyclopædia of Scientific Agric.*, Baillière, Tindall and Cox, Lond., 1931.
7. ———: The future of farming. *Scott. J. Agric.* **14**, 3, 245, 1931.
8. McCLYMONT, R. G.: The pig industry in Scotland. *Ibid.*, **14**, 4, 408, 1931.

J.

PRESERVATION
and
TRANSPORT.

42. DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH.

FOOD INVESTIGATION.

During the year, investigations have been in progress on the following topics. A full account of the work will be found in the Report of the Food Investigation Board for the year 1931.*

LOW TEMPERATURE RESEARCH STATION

(in conjunction with the University of Cambridge).

Meat.—Rapid freezing (16); by-products; the physiology of rigor mortis (20); the evaporation of water from tissues; the freezing of tissues (12, 15, 19); changes in muscle-pigments (5 and 6); changes in fats during storage (3, 13 and 14); bacteriology (9).

Fruit and vegetables (11).—Biochemical study of senescence in apples; enzymic action in the frozen state at −20 °C.; the role of acetaldehyde in the respiration of plants; temperature and the metabolic balance in the potato; the effect of ethylene on the metabolism of potatoes; the gas-storage of pears; the influence of carbon dioxide, oxygen and rate of ventilation upon the storage, ripening and respiration of bananas; cytological study of the effect of freezing temperatures on some plant tissues; internal factors determining rate of loss of water from fruit; apparatus for the critical independent control of humidity and air-movement in fruit-storage experiments; influence of fungal invasion and mechanical injury upon the rate of carbon-dioxide production of apples; the action of volatile compounds on the growth of moulds; the prevention of decay of stored fruit by the use of volatile compounds; wastage in imported fruit; low temperature injury in the cool storage of fruits and vegetables; a critical example of the effect of small differences in temperature during storage upon the storage-life of apples; vitamin content of apples (4); the preservation of fruits and vegetables in the frozen state.

Curing.—The freezing and storage of pork and mild-cured bacon; the storage of smoked bacon; the iodine number of pork fat; chemical changes in the fat of bacon during storage; the theory of curing.

Biological engineering.—Evaporation from eggs in standard packages; evaporation from apples; evaporation from cheeses; changes of freezing point in the hen's egg; movement of water in the hen's egg; behaviour of egg-yolks in aqueous solutions; gaseous exchange in infertile eggs; control of humidity in a stack of apples; the cooling of a stack of apples (18); leakage of heat into ships' insulated holds; transport by rail in insulated containers ; solid carbon dioxide as a refrigerant for transport by rail.

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* H.M. Stationery Office (in the press).

Canning (17).—Variations in the rate of corrosion of the steel-base of tin-plate ; tin-plate and the tin-iron couple ; inhibitors and accelerators of corrosion ; the corrosion of tin (7) ; the corrosion of iron.

DITTON LABORATORY.

Biological engineering.—The control of temperature, humidity and the composition of the air in the cold-storage of apples in bulk ; experiments with an uninsulated fruit store ; volatile products of the metabolism of apples ; the waxy coating of apples ; the leakage of carbon dioxide from gas stores for fruit.

Titles of papers issued during the year.

1. ADAIR, G. S., and ROBINSON, M. E. : The specific refraction increments of serum-albumin and serum-globulin. *Biochem. J.* **24**, 993, 1930.
2. ——— ———: The analysis of the osmotic pressures of the serum proteins, and the molecular weights of albumins and globulins. *Ibid.*, **24**, 1864, 1930.
3. BARNICOAT, C. R. : Rancidity changes and the flavour of fats. *J. Soc. Chem. Ind., Lond.* **50**, 361T, 1931.
4. BRACEWELL, M. F., KIDD, F., WEST, C. and ZILVA, S. S. : The anti-scorbutic potency of apples. II. *Biochem. J.* **25**, 138, 1931.
5. BROOKS, J. : The effect of freezing in a concentrated solution of sodium chloride on the colour of red muscle. *Ibid.*, **24**, 1,379, 1930.
6. ———: The oxidation of hæmoglobin to methæmoglobin by oxygen. *Proc. Roy. Soc.* B, **109**, 35, 1931.
7. BRYAN, J. M. : The effect of hydrogen-ion concentration on the corrosion of tin. *Trans. Faraday Soc.* **27**, 606, 1931.
8. GLENNIE, A. E. : Index to the literature of food investigation. **2**, 2, Sept., 1930, and **3**, 1, Mar., 1931. *H.M. Stat. Off., Lond.*
9. HAINES, R. B. : The growth of micro-organisms on chilled and frozen meat. *J. Soc. Chem. Ind., Lond.* **50**, 223T, 1931.
10. HANES, C. S., and BARKER, J. : The physiological action of cyanide. I. The effects of cyanide on the respiration and sugar content of the potato at 15° C. *Proc. Roy. Soc.* B, **108**, 95, 1931.
11. KIDD, F. : A survey of some of the principal fruit storage and transport problems of the Empire to-day. *Proc. 1st Imp. Hort. Conf., Lond.* Part III, 3, 1930.
12. KREPS, E. : The breakdown and resynthesis of phosphagen in frozen and thawed muscles. *Proc. Roy. Soc.*, B. **108**, 545, 1931.
13. LEA, C. H. : Chemical changes in the fat of frozen and chilled meat. I. Frozen mutton and lamb ; II. Chilled beef ; III. Frozen bacon. *J. Soc. Chem. Ind., Lond.* **50**, 207T, 215T, and 343T, 1931.
14. ———: The effect of light on the oxidation of fats. *Proc. Roy. Soc.* B. **108**, 175, 1931.
15. MORAN, T. : The frozen state in mammalian muscle. *Ibid.*, **107**, 182, 1930.
16. ———: A note on experimental rapid freezing. Gelatin gel for test purposes. *Cold Storage Prod. Rev.* **34**, 262, 1931.
17. MORRIS, T. N., and BRYAN, J. M. : The corrosion of the tin-plate container by food products. Dept. Sci. Ind. Res., London. *Food Investigation Sp. Rep.* 40, 1931.

18. Smith, A. J. M.: Problems of biological engineering in the cold-storage of fruit. *Proc. 1st Imp. Hort. Conf., Lond.* Part III, 60, 1930.

19. Smith, E. C.: The oxygen uptake of frozen and thawed muscles. *Proc. Roy. Soc.* B. **108**, 553, 1931.

20. ———: The heat of rigor of mammalian muscle. *Ibid.*, **107**, 214, 1930.

21. Tomkins, R. G.: The biological effects of humidity in the storage of fruit. *Proc. 1st Imp. Hort. Conf., Lond.* Part III, 78, 1930.

22. Tomkins, R. G., and Woodman, R. M.: Stalk treatment of fruit and vegetables for the prevention of stalk rot, with special reference to bananas. *J. Soc. Chem. Ind., Lond.* **49**, 285T, 1930.

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43. FRUIT AND VEGETABLE PRESERVATION RESEARCH STATION, BRISTOL UNIVERSITY.

This Station continues to act as a research and advisory centre for the canning industry in this country. The number of fruit and vegetable canneries in operation steadily increases each year, and the advice of the staff of the Research Station is constantly sought on matters connected with the opening up of new factories and the improvement of existing processes. Work in the laboratories is of necessity largely confined to the investigation of scientific problems directly connected with the improvement of the quality of English canned products, but several lines of research of a more fundamental nature have been undertaken, and it is hoped that the results will eventually prove advantageous to the industry. The testing of the suitability of the different varieties of fruits or vegetables and the investigation of new technical processes are carried out in the experimental room where small scale canning plant is installed.

Corrosion.

The chief practical difficulty preventing the canner from developing a large export trade to hot climates is the formation of blown cans through the action of hydrogen produced by corrosion of the tinplate. This problem has been examined from a number of aspects, and much useful information has been obtained. Several thousands of cans have been packed for these tests, and are stored in a constant temperature room at 95 deg. F.

Addition of acid.—Formation of hydrogen in the can occurs more rapidly in fruits naturally low in acid, and it has been shown from tests carried out during the past few years that the addition of a small quantity of citric acid to the syrup used in canning cherries and bilberries reduces the subsequent loss from hydrogen swells. In 1930 the experiments were extended to include strawberries, greengages, Victoria plums, and blackberries, but advantageous results were only obtained with cherries and greengages. During the past summer a number of further tests have been carried out, and certain alterations in the methods previously used have been made.

Inhibitors.—In laboratory experiments carried out at Cambridge certain substances were found to act as corrosion inhibitors when present in small quantities in the solution in contact with tinplate, and similar properties have been attributed to a substance occurring in commercial samples of beet sugar. In 1930 beet sugar was compared with cane sugar in the canning of raspberries, loganberries, cherries, plums and bilberries, but the results indicated that in the case of the samples tested there was no indication that any inhibitive power was detectable on a practical scale. Several new samples of sugar were obtained, and have been tested during the past season.

In the experiments carried out during 1930 an attempt was made to reduce corrosion by adding substances such as citrus pectin, agar-agar, and traces of certain amino-acids to the syrup used in canning, but the results showed that it was not possible appreciably to lessen the production of hydrogen swells by these methods

Exhaust process.—The pre-heating of the fruit and syrup in the cans before closing is an important safeguard in reducing losses from hydrogen swells, as air left in the can has an appreciable effect on corrosion, although the extent of this action is a point of dispute. In the 1930 tests, cans which had been filled with boiling syrup and sealed immediately showed greater losses from the formation of hydrogen than did others which had been exhausted at high temperatures. The results of an attempt to combine the heat exhaust and vacuum closing method are not yet sufficiently advanced to enable any statement to be made regarding this new method of treatment.

The results of corrosive action of the fruit juices on the tinplate become evident more rapidly where cans have been over-filled, or where the internal vacuum is low. As these are important factors connected with this problem, a number of tests with different fruits, exhausted under various conditions and filled to standard heights, have been made this season, and a new apparatus has been designed to measure accurately the vacua and headspaces in the cans. The effect of clinching the lids lightly on the cans before exhausting has been studied.

Method of cooling.—Rapid cooling of the cans is of importance as regards the quality of the product, but the effect of the rate of cooling on subsequent corrosion is not sufficiently understood. In the past season cans have been cooled at various rates, and certain batches have been chilled for a short period before being stored under tropical conditions.

Tinplate and lacquering.—Different types of tinplate have been tested this season, and new lacquers have been examined. It is hoped that some of these will check excessive corrosive action at high temperatures (1, 2).

During the early part of the year a bulletin (1) was compiled giving the results of the experiments on production of hydrogen swells and perforations, with special reference to the cans stored at high temperatures. This was published as a supplement to the previous bulletin on Springers, Hydrogen Swells and Perforations, and was circulated to all subscribers to the Research Station.

VARIETY TRIALS.

Fruit.

The choice of suitable varieties of fruits for canning involves so many factors that no really definite results can be obtained until a variety has been tested for three or four successive years. All the chief varieties of the principal English canning fruits have now been tested over a period of several years, and a bulletin (3) on "Varieties of Fruits Suitable for Canning" was issued from the Research Station this year. In the past season special attention has been paid to cherries and cultivated blackberries, and it is hoped to continue the investigations on these fruits during the next few seasons.

Strawberries.—As in previous seasons, the most suitable all-round variety for canning was Sir Joseph Paxton. Royal Sovereign yields good results, but is inclined to be pale and less even in colour. Oberschlesien has again given excellent results as regards the colour of the fruit, but the presence of poorly-shaped wrinkled berries in many cases is a disadvantage, and in addition the fruit is inclined to be soft. Tardive de Leopold is also a good colour, but the great variation in shape and the prevalence of malformed berries makes this variety unsuitable for general use in canning.

Some thirty varieties were canned during the season.

Raspberries.—The most popular raspberry for canning still appears to be Lloyd George ; it is firm, a good shape, a bright colour, and a pleasing flavour when canned. About twelve other varieties were tested, and good results were obtained with Pyne's Royal, Norfolk Giant, Red Cross, and Red Antwerp C.

Cherries.—Special attention has been given to the testing of cherry varieties, and, as a result of the helpful co-operation of the East Malling Research Station, 20 Kent varieties have been canned. Certain of these cherries are normally too expensive for commercial canning, but the examination of such a range of varieties makes it possible to study the desirable canning qualities in greater detail than would be possible if the scope were more limited.

Of the white cherries which are coloured for canning, the Napoleon and Kentish Bigarreaux and Governor Wood have given good results. Amongst the black varieties the small cherry Caroon has an excellent colour and flavour, while Turk and Malling Black Eagle are larger and almost equally good in appearance. The red, slightly acid varieties May Duke, Kentish Red, and Flemish Red are attractive in flavour if slightly pale in colour. As an acid cherry the Morello has a good appearance and a rich, sharp flavour.

Black currants.—Good results have been obtained this year with Davidson's Eight, Supreme, and Westwick No. 15.

Plums.—A plum which has given excellent results during the past two seasons is the Early Laxton. Medium-sized Magnum Bonums, if canned at the right stage, give a product of very fine appearance, although there is a slight tendency to bitterness in the skin. The principal canning varieties are Victoria, Yellow and Purple Pershore, Early Rivers, and Blaisdon Red.

Blackberries.—Eleven varieties of cultivated blackberries were tested. One Californian variety of unknown name has again given good results, while five samples of Himalayan Giant from different sources could be picked out as being particularly good. One lot of Edward Langley proved to be very promising.

It is hoped to repeat these tests on a larger scale next year, as there is every possibility that this fruit will prove popular when canned.

Vegetables.

Peas.—For the seventh year in succession extensive trials have been carried out on the canning of peas, and for the second season these tests have been conducted in close co-operation with the Agricultural Institutes at Kirton and Norfolk, where many of the varieties have been grown. The principal varieties generally canned in this country are Alaska and Lincoln, but quite as good, and in some cases better, results have been obtained with other varieties, notably Surprise, Advancer, Chemin Long, Canner's Perfection, and Prince of Wales (4).

Beans.—Certain varieties of stringless beans give excellent results when canned. In the tests carried out this season Keeney's Stringless Green Refugee has been the most satisfactory.

Other vegetables.—Many varieties of other vegetables, such as carrots, beetroots, turnips, new potatoes, and spinach, have been tested, and some of these may be canned with success.

QUALITY OF FRUIT.

In carrying out the examination of National Mark canned fruits it was found that a number of aspects concerning the quality of the fruit required attention; consequently the principal varieties of the different fruits were carefully examined before canning. Samples in good condition and others showing common blemishes were photographed for reference, and all round fruits, such as gooseberries, cherries, plums, and damsons, were graded through special slotting devices to ascertain the relationship between size and weight of the various grades of fruit. The effect of different methods of exhaust treatment on the quality of the final product has been studied.

BACTERIOLOGICAL STUDIES.

The possible sources of infection in canned vegetables have been explored this season. Sugars have been obtained from many commercial canneries, and these have been tested for presence of thermophilic organisms. Negative results were obtained in all cases.

TOUGHENING OF PEA MEMBRANE.

The effect of absorption of calcium and magnesium salts by the outer membrane of peas during the process of blanching has again received attention in the chemical laboratory, and useful data on the subject have been obtained.

Titles of papers issued during the year.

1. HIRST, F., and ADAM, W. B.: Experiments on hydrogen swells and perforations carried out during 1929 and 1930: with special reference to storage of cans at high temperatures. *Supplement to Canners' Bull. No. 1. Campden Fruit and Vegetable Preservation Res. Sta., June,* 1931.
2. ADAM, W. B.: Lacquer protection of fruit and vegetable cans. *Food Manufacture,* April, 1931.
3. HIRST, F., and ADAM, W. B.: Varieties of fruits suitable for canning. *Canners' Bull. No. 3. Campden Fruit and Vegetable Preservation Research Sta.,* May, 1931.
4. ———— ————: Varieties of peas suitable for canning. *J. Min. Agric.* **38**, 1, 38, 1931.
5. HIRST, F.: Facts and fallacies relating to canned foods. *Canning Supplement to the Manchester Guardian Commercial,* May, 1931. Popular article.

K.

AGRICULTURAL ENGINEERING.

44. INSTITUTE OF AGRICULTURAL ENGINEERING, OXFORD UNIVERSITY.

Survey of Mechanised Farms.

At the beginning of the year it was decided to collect information bearing upon the question of the mechanisation of agriculture as it presented itself in this country. For a study of mechanised farming in Canada and the U.S.A., see (3). Seven farms in which appreciable progress in this direction was being made were selected, and their owners very readily expressed their willingness to allow members of the Institute staff to make the necessary investigations. These farms are by no means uniform either in character or purpose, and include not only purely arable but livestock farms as well. It is hoped that by studying, recording and contrasting the methods and machinery employed and the results attained, valuable information will be procured on which principles for future guidance can be based, and the new methods, consequent upon the change over from horse to mechanical traction, established on right lines. The survey is being carried out in co-operation with the Agricultural Economics Research Institute. Regular visits are paid to the farms, and observations of economic, mechanical and agricultural interest are being made. It is hoped to increase the number of farms under survey in the coming year. A preliminary note dealing with the scope of the survey is in course of preparation.

Several enquiries have been received from Colleges in Oxford owning agricultural land regarding the possible development of mechanical equipment. This problem is being vigorously taken up, and the Institute is anxious to co-operate as closely as possible with any of the Colleges to whom it can be of service in this connection, as it is hoped that much information of direct value will accrue from this development.

Research.

Tractors.—Work is being carried out on the adhesion of tractor wheels. This was rendered possible in the first place by the loan by the Ford Company of two tractors with alternative sets of wheels and tracks. A novel method, which will make the measurement of the performance of tracks entirely independent both of the characteristics of the tractor and the physical properties of the soil, is being tried. A new dynamometer recording unit for the purpose, which marks a very considerable improvement on previous instruments, has been designed and built in the Institute. As the outcome of this work it has been found possible to produce a light and accurate dynamometer equipment at considerably smaller cost than has so far been possible, and it is hoped, within the next few months, to produce a simple dynamometer unit which can be supplied at a low price to other institutions in this country who require such an instrument.

Dilution of crankcase oil.—Work on this subject has been discontinued, as adequate arrangements have been made for the carrying out of these tests in other laboratories more suitably equipped for the purpose.

Mole draining.—Apparatus has been designed for accurate dynamometry of mole draining ploughs, for obtaining a continuous and automatic record of the outflow from drains, and for the measurement of depth of water-table and soil temperature. Arrangements have been made with various landowners round Oxford to carry out experiments on their land, but the Institute is anxious to find a small area of heavy land over which it can have entire control for the next few years.

Seed drills.—Work has been begun on the mechanism of seed drills. Some laboratory tests on a drill of the external force feed type tended to show that no great amount of adjustment would be necessary in order to obtain a fair distribution as between coulter and coulter. The question of regular distribution in each row seems, however, somewhat more difficult. A simple laboratory instrument for obtaining an autographic record of the distribution in each row has been constructed, and further experiments are in progress.

Combine harvester-thresher.—The Institute has been co-operating with the Ministry again during the past season, and a number of extremely useful results have been obtained in spite of the very wet season. Moisture contents of harvested grain were in many cases very high, as much as 27 per cent. being frequently recorded, and satisfactory harvesting would, in many cases, have been impossible without the use of drying equipment, of which the Institute has made a special study. A short occasional paper on the subject has been prepared. On the development and use of the combine in Canada and the U.S.A., see (3).

Grain drying.—The whole problem is being reviewed and it was decided to re-examine the subject of the effect of the temperature of grain drying in these laboratories during the winter, having special regard to the germination of grain and the effect of drying temperature, moisture content, age and storage conditions on this. The Institute wishes to acknowledge the co-operation of the Botanic Gardens in this respect.

Moisture testing.—In view of the importance of moisture content of grain to the farmer, arrangements have been made for the routine testing of moisture content in these laboratories. A very large number of tests have been carried out this season in connection with the combine and other experiments. Experiments on the method of moisture testing by means of change of electrical resistance have been discontinued as unsatisfactory for various reasons. At the same time a very cheap and simple method for use by farmers has been suggested and is giving very promising results in the laboratory.

Soil mechanics.—It is considered essential to the work of the Institute that some method of correlating soil properties with drawbar pulls should be found. The whole subject of soil mechanics is being explored, and it is hoped shortly to produce new methods which will be valuable in this respect. At the same time the problem of recording such complex subjects as the work of the plough and the production of tilth are being investigated.

Soil heating.—In view of the increasing use of electricity for the heating of soils in frames, an investigation has been begun on this subject. It is hoped that, apart from results of purely economic and engineering importance, data of considerable scientific value regarding movement of heat in soils and of losses at soil surfaces will be forthcoming (1, 2; 4).

Grain cleaning.—A review of the subject is in preparation, which should point the way to substantial improvements in grain cleaning and winnowing in the field. A simple vertical wind channel for experiments on winnowing problems has been built in the laboratory and is now running.

Soil physics.—The Institute is co-operating with the Soil Science Research Laboratory in the investigation of a number of physical and physico-chemical problems, which have a more or less direct bearing on the mechanical properties of soils, and is assisting in the design of special apparatus for this work, which will be mainly carried out as post-graduate research.

TESTING.

Ministry's testing scheme.—During the year tests have been completed on an Austin tractor and a Fordson tractor. A test on a mowing machine submitted by Messrs. Harrison, McGregor & Co. Ltd., is still in progress.

The Ministry has now published reports on all the tests which have been completed since the first test in 1926. " The First Report of the Agricultural Machinery Testing Committee " contains copies of twenty certificates and reports issued up to July, 1930, while five other certificates and reports have since been issued separately.

Royal Agricultural Society of England.—Following the procedure inaugurated in 1928, reports on eight machines entered as " new implements " for the Society's Silver Medal at the Royal Show at Warwick were submitted by the Institute, with the co-operation, for two of the reports, of the National Institute for Research in Dairying.

Titles of papers issued during the year.

1. Owen, B. J.: Agricultural engineering. *Agricultural research in* 1929. John Murray, Lond., 1930 (for the Royal Agricultural Society of England).
2. Cameron Brown, C. A.: The use of electricity in horticulture, *J. Min. Agric.* **38**, 2, 132, 1931.
3. Baxter, T., Clarke, G., and Newman, J. E.: Agricultural machinery in Canada and the United States of America. *Min. Agric. Bull.*, No. 27, 1931.
4. Cameron Brown, C. A.: Electricity and farming. *Electrical Rev.*, July 3, 1931.

II.

LOCAL INVESTIGATIONS
at
ADVISORY CENTRES.

I.

CHEMISTRY.

45. ABERYSTWYTH : UNIVERSITY COLLEGE OF WALES.

The following investigations have been completed:—(*a*) the chemical composition of edible weeds, and (*b*) the influence of manures on the yield as well as the botanical and chemical composition of upland and lowland pastures. The result of both these investigations will appear in the Welsh Journal of Agriculture. Other problems under investigation are (*a*) the mineral content of various species of grasses and clovers grown in different soils at varying altitudes, and (*b*) the mineral content of certain species of grasses grown in mixtures as compared with the same species grown in plots and drills. These two latter investigations have been undertaken in conjunction with the work of the Welsh Plant Breeding Station on hill pastures, with the object of ascertaining, if possible, to what extent the composition of grasses more or less indigenous to the lowlands is influenced when grown on the uplands or poorer types of soil. The results obtained from the investigational work in previous years have been published (1, 2, 3). The last two of these papers are the outcome of previous pasture work and were undertaken in order to elucidate points that arose in this connection. The paper on oats gives the results of some preliminary work of a fairly extensive investigation undertaken on the composition of oats, the principal cereal grown in this Province.

Titles of papers issued during the year.

1. FAGAN, T. W., and WATKIN, J. E.: The distribution of the nitrogenous and mineral constituents in the oat plant at different stages of growth. *Welsh J. Agric.* **7**, 1931.
2. FAGAN, T. W., and MILTON, W. E. J.: The chemical composition of eleven species and strains of grasses at different stages of maturity. *Ibid.*, **7**, 1931.
3. FAGAN, T. W., and DAVIS, R. O.: The recovery of nitrogen in pastures from the application of nitrogenous manures. II. The recovery of nitrogen in ordinary swards. *Ibid.*, **7**, 1931.

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46. BANGOR : UNIVERSITY COLLEGE OF NORTH WALES.

The principal task in the Agricultural Chemistry Department is the soil survey of Wales (2). The work has now settled down along the routine lines which are being generally adopted throughout the country. It is satisfactory to record that the "series" system of soil classification is working well in practice. Messrs. D. O. Hughes and W. G. D. Walters have been mapping during the past season in Flintshire and Denbighshire. A progress report on the work of the past two years will appear in the next volume of the Welsh Journal of Agriculture.

Mr. W. McLean has continued his investigations on the nature of soil organic matter and has published work which adds appreciably to existing knowledge of the subject (3 and 4).

Mr. Rice Williams has carried further his investigations on the exchangeable bases of soils and has prepared a paper on the exchangeable bases of carbonate soils and the relative contribution of clay and organic matter to exchange capacity.

The adviser is continuing his investigations on the character of the soil profile as shown by the composition of the clay fraction (1). The numerous soil samples from overseas which have come to hand in connexion with the work on mechanical analysis (see report on p. 340) have provided material for some interesting comparisons, particularly with regard to the degree of weathering of soils.

Titles of papers issued during the year.

1. Robinson, G. W.: The development of the soil profile in North Wales as illustrated by the character of the clay fractions. *J. Agric. Sci.*, **20**, 618, 1930.
2. ——————: Soil surveys. *J. Min. Agric.* **38**, 4, 379, 1931.
3. McLean, W.: Effect of hydrogen peroxide on soil organic matter. *J. Agric. Sci.*, **21**, 251, 1931.
4. ——————: The nature of soil organic matter as shown by the attack of hydrogen peroxide. *Ibid.*, **21**, 595, 1931.

47. BRISTOL UNIVERSITY.

Grass Land.

Longleat grazing and manuring experiments.—These form the subject of a separate report (see p. 338). The field work came to an end during October, 1931, after having been in progress for five years.

Pasture experiments.—Sampling of the herbage on the trial plot situated on the Marlborough Downs has been continued during the present season, and arrangements have been made to continue the work, so far as this centre is concerned, for a further period. The chemical analysis of the herbage, formerly carried out elsewhere, will in future be conducted at Bristol.

Nutritive value of pasture grass and hay.—The chemical examination of a thousand samples of grass and hay, which have been collected from trial centres in the Province, has been continued during the year. It is hoped that these data will provide information as to the relative feeding value of grass and hay grown under different conditions of soil, manuring, altitude and cultivation (1). Attention is being paid to the feeding value of winter grass.

The eradication of bracken.—A full report of these experiments, which have been in progress since 1921, has been published (2).

ARABLE LAND.

Sugar beet.—The manuring of sugar beet on light acid soils in the north of the Province has received further attention, and striking results have been obtained from the use of basic slag as the source of phosphate. No additional advantage was apparent from the use of lime in conjunction with the slag. A full report of these experiments will appear in the Journal of the Bath and West and Southern Counties Society (1931–2).

Flax.—Investigations on the manuring of flax grown for fibre in the south and west of the Province have been continued. The results obtained in the 1930 trials indicated that the quantities of phosphatic and potassic fertilisers usually employed could be decreased, or conversely the amount of nitrogen increased, and it is this aspect of the problem which is at present receiving attention.

Mixed corn crop trials.—A comprehensive series of winter and spring sown mixed corn crop trials was carried out in the Bristol Province (and in one county of the Harper Adams Province) and the following conclusions drawn :—

(*a*) The success of these crops depends on suitable climatic conditions and varieties of cereals and legumes.

(*b*) During the season under review there was a reduced yield in the case of winter sown crops as compared with the single crop controls.

(*c*) The depredation of birds seriously affected the yields from the spring sown crops.

(*d*) The growing of such crops would appear to be justifiable only when the cost of purchased protein foodstuff is high in relation to the price of milk or other commodity sold off the farm.

Seeds mixture and clover trials.—The temporary and permanent ley trials have been continued. The investigation of the value of Canadian Arctic White Sweet Clover as a forage crop, which has been in progress for two years, has been concluded. The plants which were sown in May, 1930 (inoculated and uninoculated) had all died by September, 1931.

Although a high yield of material per acre was obtained, the fibre content was very high (33 per cent. of the total dry matter) and that of protein comparatively low. The material cut green was not readily taken by stock, and in certain instances it was completely refused.

Weed eradication.—The usefulness of sodium chlorate in the control of weeds is being investigated.

Titles of papers issued during the year.

1. LING, A. W. : Grass as a foodstuff. *J. Wilts. Assoc. Dairy Students*, Nov., 1930.
2. LING, A. W., and WALLACE, T. : The eradication of bracken. *J. Bath and West Soc.* VI Series, **5**, 1930-31.

48. CAMBRIDGE UNIVERSITY.

Liming.—In view of the volume of advisory work on this point and the lack of precise liming experiments in this Province, experiments designed to provide reliable information have been established on the main soil types on which the question of the desirability of liming arises. As far as possible the centres are selected with a view to their remaining under observation for a period of years. The experiments were in all cases laid down in co-operation with the County Staffs, who have given willing and generous assistance in the field work. Four centres have been established in the past season.

Further observations have also been made on the Tunstall liming plots in East Suffolk. These are under the direct control of the Organiser for East Suffolk, who has given every facility and encouragement to the work. Information of considerable value in local advisory work has been obtained from these plots, and though they were not laid down in accordance with modern ideas of plot technique it is hoped that they will provide a fair estimate of the length of time for which the original dressings of chalk will remain effective in the circumstances prevailing in this district.

Potato sickness.—Further observations and preliminary field trials were made in connection with this trouble in Bedford and Cambridge. It is hoped that field trials on similar lines will be carried out in 1932 in conjunction with the Advisory Biologist and the County Staffs.

Poultry manure.—Experiments on the drying of poultry manure are in progress in conjunction with the Agricultural Organiser for West Suffolk.

Manuring of market garden crops.—The Advisory Chemist has co-operated with the Agricultural Organisers for Bedford and Cambridge in experiments on the manuring of early potatoes and brussels sprouts on the light Greensand and Valley Gravel soils.

Tomato culture.—An investigation (in collaboration with Drs. Mackenzie-Taylor and R. M. Woodman) into the trouble caused by continual use of water with a high content of sodium chloride for watering tomatoes under glass has been concluded and a report published (2).

Titles of papers issued during the year.

1. HANLEY, F.: *Report on the results of demonstrations carried out on the sugar beet crop in the Fenland districts of the Isle of Ely and Huntingdonshire during the seasons* 1927 *and* 1928. Privately printed.
2. TAYLOR, E. McK., WOODMAN, R. M., and HANLEY, F.: A note on the reclamation of a greenhouse soil containing sodium clay. *Chem. News and J. of Industrial Service*, Nov. 13th, 1931.

49. HARPER ADAMS AGRICULTURAL COLLEGE.

Soil survey.—The work during the year included the mapping of 30,000 acres (two six-inch ordnance sheets) and the identification and classification of 23 main soil series. This formed the first year's work using the revised methods and part of a scheme intended to include a large section of the North Shropshire Plain.

Liming experiment.—A "Class A" liming experiment on the Bridgnorth Soil Series (Bunter Sandstone) commenced in 1928 has given interesting results this year with sugar beet.

The area was laid out in a Latin square with a quadruplicated series of four dressings of carbonate of lime.

0	25	50	100	dressings of lime, cwts. Ca CO_3 per acre.
4·05	9·09	10·25	10·09	yield of sugar beet, tons per acre.

Data relevant to changes in soil acidity (initial pH. 4·5–4·9), lime requirement, exchangeable calcium, &c., have been obtained. It is intended to continue the experiment for a period of ten years.

Grassland experiments.—(*a*) Basic Slag Committee's experiment in form of a five replicate Latin square. Yield measured in tons of hay per acre.

(*b*) Manurial experiment on peat grassland. Interim results indicate a definite response to both phosphatic and potassic fertilisers, the combined effects being additive.

(*c*) Continuation of the small grass plots in connection with the Development Commission pasture experiments.

Changes in composition of sugar beet during storage.—Conclusion of three years' experiments (1).

Titles of papers issued during the year.

1. Davies, W. M., and Wilson, T. O.: The storage of sugar beet on the farm. *J. Min. Agric.*, **38**, 8, 806, 1931.
2. Davies, W. M.: Cultivation of the sugar beet crop. Three years' investigation of the effects of spacing. *Ibid.*, 32, 10, 973, 1931.

50. LEEDS UNIVERSITY.

Sugar beet.—Investigations on the sampling and composition of sugar beet have been completed and were the subject of a paper recently published (1). It was shown, amongst other findings, that except for very small crops a sample of beet to be representative should contain at least 50 roots. Evidence is adduced to show that the factory method of sampling is inaccurate, and that small roots are definitely richer in sugar and in dry matter than large roots.

" Carr " soils.—Laboratory work on " Carr " soils has been brought to a stage when some of the findings require confirmation by field experiments. It is hoped to commence these at the earliest possible moment.

Ammonium bicarbonate.—The value of ammonium bicarbonate—an industrial by-product—as a fertiliser has been tested by pot experiments. Although the experimental error in such tests is very high, it is clear that ammonium bicarbonate gives increases in yield and does not exert a toxic effect. Two field experiments with this material are being arranged.

" Finger-and-toe " disease.—An experiment on the Latin square principle was conducted to test the relative value of different forms of lime on land infected with " finger-and-toe." This experiment did not confirm the current view that liming alone reduces " finger-and-toe " on turnips. A period of rest between two successive root crops of at least nine years is an effective factor in reducing the incidence of this disease.

Basic slag.—Two experiments (in conjunction with Rothamsted Experimental Station) are being carried out on the phosphatic manuring of meadow hay. Results at one centre are not significant, but at the other, where the soil is composed of boulder clay, the results show that superphosphate and basic slag of high citric solubility are decidedly more effective in the first year than are North African phosphate and slag of low solubility.

Title of paper issued during the year.

1. Milne, G., Jones, H. T., and Willcox, J. S. : Some investigations on the sampling, analysis, and composition of sugar beet. *J. Soc Chem. Ind.*, **50**, 18, 155T.

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51. MANCHESTER UNIVERSITY.

Control of " grey leaf " disease.—A preliminary investigation of the effect of manganese sulphate treatment on the control of " grey leaf " disease in oats was carried out. The result was inconclusive owing to the unavoidable lateness of application, and the experiment will be continued next season.

Potato sickness.—In conjunction with the Advisory Entomologist a comparison between the effects of equivalent dressings of urea and calcium cyanamide was attempted on an area showing potato sickness disease where cyanamide treatment had been proved to be effective as a partial control measure.

Laboratory work.—The laboratory investigational work included the examination of methods recommended for the estimation of ammonia, nitrite and nitrate in soils, and a colorimetric method for the determination of ammonia and nitrate was developed. The work commenced last year on the state of chemical combination of the soil phosphoric acid has been continued.

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52. MIDLAND AGRICULTURAL COLLEGE.

Molassed beet pulp enquiry.—As stated in the previous year's report, this investigation is being carried out in co-operation with the National Institute for Research in Dairying, Reading. During the past season further feeding experiments have been carried out at both centres, and the results obtained indicate that the problem is an exceedingly complex one. The production of a fishy taint in milk cannot be attributed to one or two simple factors and it appears that type of pulp (due to method of manufacture), quantity of pulp fed, time of feeding relative to milking, and individuality of the animal, are all significant factors. At the Midland Agricultural College a large number of samples of molassed pulp and molasses were received from the factories ; these were subjected to anaylsis, the percentages of nitrogen representing various groups of constituents being determined. There appears to be great variation in composition in this material. The present stage of this investigation indicates that physiological and chemical research into the nature of these compounds and the changes they undergo in the digestive system of the animal, is desirable before further feeding experiments are conducted.

Destruction of mites in cheese.—Cheese mites (*Tyroglyphus longior*) are a pest in many dairies, more particularly in those where Stilton cheese is made. Considerable monetary loss is experienced every year by the makers of this cheese in the Midland area. Successful control of this pest has been obtained in some instances by the use of carbon disulphide, but unfortunately this insecticide is very inflammable, and the vapour forms a highly explosive mixture with air. Such a liquid in the hands of inexperienced persons might lead to disastrous results, and therefore research has been instituted (with the aid of the Advisory Entomologist) to discover an insecticide which would destroy the mites, and at the same time not injure the saleable condition of the cheese, and also one which can be handled quite safely by a cheese maker. Many substances have been tried on a small scale and arrangements are being made to try one or two of these in cheese stores this coming winter.

Failure of cereals in spring.—This investigation has been continued during the past season, samples of cereals from good and bad patches on various fields in the Midland area having been collected, and analysis of these samples is now being carried out. No definite indications of the cause of these failures can be reported, but the results of analysis indicate striking differences in the mineral content of these crops.

Variation in the composition of milk.—The effect of climatic conditions on the quality of milk has been studied by comparing data obtained during the year 1929 with records of other years (1).

The data obtained during the recording of the day-to-day variation in the composition of the milk of the College herd during 1928–30 is being examined and a considerable amount of information obtained. The results of this examination will be published later.

The valuation of milk on a quality basis is being studied, and arrangements have been made to try out a system of milk purchase based on the quality factor only, facilities having been provided by a milk depot.

Titles of papers issued during the year.

1. CRANFIELD, H. T.: The effect of abnormal weather conditions on the quality of milk. *J. Min. Agric.* **37**, 4, 347, 1930.
2. ———: Lime and the soil. *Derbyshire Farmer,* **11**, 5, 1931.
3. ———: The influence of feeding on the quality of milk. *Berks Farmers Yr. Bk.,* 1931.
4. ———: The importance of variation in composition in the production and distribution of milk. *The Milk Trade and Farmers' Gaz.,* **2**, 2. 3 and 4, 1931.

53. NEWCASTLE : ARMSTRONG COLLEGE, DURHAM UNIVERSITY.

A study of factors affecting soil reaction values as determined by the quinhydrone electrode.—The effects of soil-water ratio and weight of quinhydrone used on the reaction value of two soils have been investigated. All estimations were adequately replicated, and the results submitted to statistical treatment.

With an acid soil the soil-water ratio of 1 : 1·5 gave the smallest variance. There was no significant difference between the variance of the soil-water ratios 1 : 0·5, 1 : 1, and 1 : 1·5 in the case of a limed soil.

The weight of quinhydrone necessary per unit volume of a standard soil suspension was shown to be less than that generally employed.

This work, which was carried out with the assistance of Mr. F. J. Elliott, B.Sc., A.I.C., has now been completed (3).

The yield and composition of pasture grass from selected plots on Tree Field, Cockle Park.—The field work necessitated by this investigation was carried out by F. J. Elliott during the growing season of 1930, and the analytical work is nearing completion.

Lime-requirement studies on some of the more important soil types in the Province.—Small plot liming experiments on the 5×5 Latin square are in progress at two centres.

An investigation into the effect of soil reaction on the composition of cereal crops.—The material for this work has been obtained from the small-plot liming trials referred to above. Results are not yet available.

Soil survey.—A soil survey has been initiated in North Northumberland (Tweedside) but, in view of the limited time and facilities available for this work, rapid progress is not anticipated.

Titles of papers issued during the year.

1. Thomas, B., and Simpson, T. W.: A study of soil reaction in some experimental drainage plots at Cockle Park. *J. Soc. Chem. Ind.*, **50**, 37, 349T.
2. Thomas, B., and Hargrave, J.: The composition of kitchen waste. *J. Min. Agric.*, **38**, 4, 366, 1931.
3. Thomas, B., and Elliott, F. J.: Some factors affecting soil reaction values as determined by the quinhydrone electrode. *J. Soc. Chem. Ind.*, **50**, 33, 303T.
4. Hall, A. A., and Hargrave, J.: A preliminary investigation into the seasonal variations in the composition of pasture under different manurial treatments. *Ibid.*, **50**, 19, 167T and May 8th, 1931.

54. OXFORD UNIVERSITY.

A good deal of work has been done by the Advisory Chemist, in conjunction with Mr. Skilbeck, of the staff of the School of Rural Economy, on the co-ordination of air and ground surveys. A paper on this subject has been prepared for the Soil Survey Conference.

A survey of the Market Harborough grazing area was made by a research student working under the supervision of the Advisory Chemist. This is being prepared for publication.

An experiment to study the movement of ions in soils, under artificially controlled climatic conditions, and over a long period, has been begun.

55. READING UNIVERSITY.

Solids-not-fat in milk.—Investigations commenced last year on a herd of Friesian cows, giving abnormally low solids-not-fat, have been continued and extended. Feeding experiments have been conducted and much useful data obtained.

Fruit and soil survey.—A survey is being carried out on an area mostly under fruit in north-west Berkshire, using new survey methods. Soil and pomological data are being collected and mapped on 6 inch maps.

Seakale.—Experiments are being conducted on the manuring of seakale with special reference to the production of the most satisfactory crowns for forcing.

Marrow-stem kale.—Investigations into the effect on the food value of marrow-stem kale when subjected to different methods of cultural treatment have been commenced.

Horticultural crops.—Investigations on the treatment of certain crops, with special reference to lime-induced chlorosis, have been successful, and are being followed by trials of various treatments to assist in obtaining good stocks for propagation purposes, etc.

Liming experiments.—Liming trials in south Hants. (begun by the previous adviser) have been followed up, but the results so far obtained have been more or less insignificant.

Titles of papers issued during the year.

1. Pizer, N. H.: A survey of the soils of Berkshire. *Univ. Reading Bull No.* 39, 1931.
2. Nicholson, M. N.: Report on potato fungicides used locally as dry sprays. *Kirton Agric. Inst. Leaflet,* Nov., 1930.

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56. SEALE-HAYNE AGRICULTURAL COLLEGE.

Strawberries.—The failure of strawberries at the Devon County horticultural plots at Bere Alston and on similar soils in the Tamar Valley has been the subject of further investigation during the past year. Factors other than soil conditions enter into the problem, but it appears that these can in many cases be overcome by manurial and other treatment of the soil, which has been based chiefly on the results of regular periodical analytical work.

Liming trial.—The crop results for the fifth year have been obtained, and samples both of soil and crop taken for laboratory examination.

Potato eelworm.—A detailed investigation into the failure of potatoes in large patches on the Sidmouth allotments has been started. A small plot has been set aside by the Allotment Committee for experimental work to be carried out by the Advisory Chemist and Entomologist, and a quantity of soil has been obtained for pot culture trials.

Toxic effect of lime.—The abnormal harmful effect of heavy dressings of sea sand or lime on certain Cornish soils has been the subject of further work with pot culture. The supplementary laboratory examination has shown that some of the inactive arsenic compounds appear to be rendered soluble with heavy dressings of lime, or at any rate exchangeable on the acid side. It is not yet known how far this fact may explain the phenomenon in question until this particular point has been more fully studied.

Pasture grass.—The effect of intensive manuring on the quality of pasture grass with special reference to the time of cutting has been again investigated. The composition of the herbage, especially the total and pepsin HCl soluble proteid appears to vary within wide limits determined more by the distribution of rainfall over the growing period than by the actual time of the year. The mineral constituents of the ash show a variation less affected by the rainfall.

Soil survey.—The system of classification adopted by the Soil Survey Conference has proved to be very suitable for survey work in South Devon. The soil series for a large area have now been finally determined, and progress in mapping is becoming easier and more rapid.

The Soils Correlation Committee visited the area on April 9th and 10th, and inspected the main soil series which appear on the map completed up to that date.

Adverse weather conditions which persisted throughout the spring and summer, combined with the rank growth of all crops, seriously interfered with this work during this period.

57. WYE: SOUTH-EASTERN AGRICULTURAL COLLEGE, LONDON UNIVERSITY.

Laboratory and field work has been undertaken by Mr. Martin on a variety of insecticides and fungicides, and he has given special attention to the preparation, analysis and ovicidal properties of tar and mineral oils (4). In the field work he has collaborated with the Entomological Department and also in the harvesting and drying of the crop from the experimental pyrethrum plot. The large scale spraying trials against apple scab which have been in progress for some years—in collaboration with the Mycological Department—were continued (1, 2). The trials at the Teynham farm were brought to a conclusion.

Kent fruit soils survey.—Twenty-eight soil series have been established on the Lower Greensand and it has been possible to fit most of the soils of importance to fruit-growers into this classification. The number of series has been kept as low as possible to facilitate correlation with the pomologists.

At the beginning of April the survey moved to another formation —the Hastings Beds—where fruit is also extensively grown. So far 10 or 12 soil series have been distinguished, some of these being of considerable extent and economic importance. A closer acquaintance with this area indicates that it will be necessary to give to it more time than was contemplated.

Titles of papers issued during the year.

1. Bagenal, N. B., Goodwin, W., Salmon, E. S. and Ware, W. M.: The control of apple scab. 1. Bramley's seedling. *Jn. S.E. Agric. Coll.* 28, 188, 1931.

2. GOODWIN, W., SALMON, E. S. and WARE, W. M.: The control of apple scab. 2. Allington Pippin and Newton Wonder. *Ibid.*, 28, 196, 1931.
3. MARTIN, H.: Chemistry and plant protection. *Nature.* **126**, 760, 1930.
4. ————: The examination of tar and mineral oil insecticides. *J. Soc. Chem. Ind.* **50**, 91T, 1931.
5. ————: The preparation of oil sprays. 1. The use of oleic acid as emulsifier. *Jn. S.E. Agric. Coll.* **28**, 181, 1931.

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58. EDINBURGH AND EAST OF SCOTLAND COLLEGE OF AGRICULTURE.

Potatoes.—The general results of the investigation on the discrimination of varieties by chemical tests have been published (1, 2). Dr. Smith is continuing this investigation.

The capillary electrode (4) devised by Dr. Smith and Dr. Robertson for this investigation has excited considerable interest on the Continent and is now described in the leading German text books; a modified form has proved suitable for physiological investigations.

Storage of potatoes.—A series of experiments was carried out to ascertain the conditions under which immature potatoes can be stored without impairing their characteristic quality and flavour (5).

Composition of pastures.—The investigation into the effect of nitrogenous manuring on the composition of pasture, which was begun in 1930 by Dr. Lauder and Mr. J. M. McGillivray at the farm of Broomlee Mains, West Linton, has been transferred to the College farm at Boghall; samples of the grass were taken at monthly intervals and the detailed analysis of these is now in progress. Botanical analyses of the pasture were also made by Mr. Fenton throughout the growing season.

Soil investigations.—Dr. Andrew Comrie has now completed his investigation of the effect of liming on the acidity of a very acid soil, and the results are now ready for publication. It is shown that the assimilation of lime in the field is much slower than that indicated by the laboratory methods, and that to produce the same result about double the quantity of lime is required in the field.

The investigation into the causes of the fluctuation in the acidity of soils during the growing period of the plant, begun in 1929 by Dr. A. M. Smith and Dr. I. M. Robertson, is being continued by Dr. Smith and Mr. A. Robertson. The results obtained in the first stage of investigation have been published in the Journal of Agricultural Science (3). The investigation is being continued.

Effect of nitrogenous fertilisers.—The experiments commenced by Dr. Smith in 1929 on the effect of the time of application of top dressings on the composition of the grain are still in progress. The 1930 results showed significant differences and the experiments have been repeated and extended in 1931.

Titles of papers issued during the year.

1. Lauder, A., and Robertson, I. M.: Indentification of potato varieties by chemical tests. *Scott. J. Agric.* **14**, 1, 47, 1931.
2. Robertson, I. M., and Smith, A. M.: A study of the hydrogen ion concentration of the potato tuber. *Biochem. J.* **25**, 763, 1931.
3. Smith, A. M., and Robertson, I. M.: The influence of the plant upon seasonal changes in soil acidity. *J. Agric. Sci.*, **21**, 822, 1931.
4. Robertson, I. M., and Smith, A. M.: A capillary electrode suitable for the determination of the hydrogen-ion concentration at a point on plant tissue. *J.S.C.I.*, **49**, 120T, 1930.
5. Smith, A. M.: The storage of new potatoes. *Scott. J. Agric.*, **15**, 2, 202, 1932.

59. GLASGOW: WEST OF SCOTLAND AGRICULTURAL COLLEGE.

Soil investigation.—The examination of all the samples, numbering over three thousand, has been completed in the laboratories of the Central College in Glasgow. Valuable assistance was received from post graduate students and from senior pupils of Glasgow secondary schools during vacation periods.

The following maps have been prepared from the analytical data:—

(*a*) soil texture, (*b*) lime requirement, (*c*) pH value, (*d*) phosphate content.

A mechanical and chemical analysis has been made of 84 samples chosen as being representative of the various textures occurring within the area.

A map is at present being prepared showing the boundary of each farm, and it is proposed to indicate on it the types of farming.

A report on the soils of South Ayrshire is being drafted.

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60. ABERYSTWYTH : UNIVERSITY COLLEGE OF WALES.

Damage by tar distillate washes.—The cause and nature of damage to fruit trees by tar distillate washes is being enquired into. This damage is fairly common, especially on the western seaboard with its moist mild weather conditions in winter. The effect of variety, situation, local weather conditions, and time of spraying upon resultant damage are all being investigated.

Carrot fly and onion fly.—Extensive experiments were carried out against the carrot fly and onion fly, but the non-appearance of these pests in significant numbers rendered the experiments abortive.

Virus diseases of potatoes.—Varieties and strains of potatoes apparently very resistant to virus diseases having been obtained from various local sources, these strains were grown alongside control varieties. The resistance or otherwise to virus diseases is being tested, and should significant resistance be found it is hoped by judicious selection to build up satisfactory stocks from the yield point of view also. The comparative aphid infestation of the various varieties of potatoes grown was ascertained.

Control of ants.—Several complaints having been received of damage by ants in pastures and grass orchards, opportunity was taken of the presence of numerous ant hills in the garden orchard to investigate their control. The use of a solution of calcium cyanide, was found to be the most effective method.

Mineral oil washes.—Preliminary work was commenced on the effect of mineral oil fruit tree washes under local conditions.

61. BANGOR: UNIVERSITY COLLEGE OF NORTH WALES.

Sheep maggot fly.—Investigations concerning the problem of *Lucilia sericata* (sheep maggot fly) have been continued, but the slight infestation prevented the elaboration of direct control measures. Special attention has been given this season to the relative infestation among different breeds of sheep.

Collembola.—The biology and control of certain economic species of Collembola has received attention, while systematic studies in this group have been centred in the Collembola of the Anglesey sand dunes.

Potato aphides.—The results of a joint investigation (1928–1931) including the relationship of aphid infestation to the production of seed potatoes are in the press. This work and the need for critical field studies on the potato aphides has led to a detailed investigation on the ecology of potato aphides, in particular *Myzus persicae* and *Macrosiphum gei*. The nature of the initial infestation has been studied, and the curve of the infestation of the species concerned, with dates of initial, maximum and final infestation in the field, has been ascertained. The incidence of potato aphides in 1931 was below that of the four preceding years. Records of daily and weekly movement of the aphid population within the crop have been secured. Comparative ecological studies of the aphid population at successful and unsuccessful seed producing centres have been carried out.

Warble fly.—The value of large scale treatment of cattle with derris powder wash for the control of warble flies has been demonstrated, for in Aberdaron district an infestation of 14·2 warbles per animal in 1930 was reduced to 2·2 per animal in 1931, whereas within a mile outside the treated area the average number of warbles per animal was 15·7. There was ample evidence of the local habit of the fly. Extended demonstrational areas include Bardsey Island, Nant Peris Pass, Nebo in Caernarvonshire, and Rhoscolyn in Anglesey, all of which it is hoped will prove environmental islands of the pest. The value of dry derris powder in the destruction of warbles has been demonstrated (2).

Titles of papers issued during the year.

1. Davies, W. M.: The influence of humidity on Collembola. *Rep. Agric. Meteor. Conf.*, 1930.
2. ————: Control of warble flies in North Wales. *J. Min. Agric.*, **37**, 9, 862, 1930.
3. ————: The "many-necked" condition of swedes in relation to varietal and manurial trials. *Welsh J. Agric.*, **7**, 319, 1930.
4. ————: Trials on the control of certain horticultural pests in North Wales. *Ibid.*, **7**, 332, 1930.

62. BRISTOL UNIVERSITY.

Field trials with tar distillate-heavy paraffin washes.—Following up the successful trials against *Lygus pabulinus* in 1929–30, further field trials both against this species on black currants, and against *P. rugicollis* on apples, were carried out at a number of centres using tar distillate-heavy paraffin washes in varying proportions. Two types of paraffin, "white" and "half white," were tested. The results against *Lygus* were again highly satisfactory. In the case of *Plesiocoris* the tar distillate-heavy paraffin washes gave results superior to those of the "high neutral" type used alone, but failed completely at one centre, and to a large extent (on the variety Bramley Seedling) at another. "High neutral" tar oil type wash failed to give a satisfactory commercial control at several centres.

Apple sawfly (*Hoplocampa testudinea*).—It is desirable to determine the best time of application of a nicotine wash for the control of the apple sawfly, and experiments with this object were carried out on the apple variety Worcester Pearmain. The most efficient control was obtained by spraying the fruitlets five to seven days after blossom fall.

The relationship of Lygus pabulinus to markings on apple fruit.—Preliminary experiments carried out under field insectory conditions failed to show that the capsid was responsible for any fruit markings. Further experiments have been arranged to obtain confirmatory data.

Correlation between the salicin content of willows and susceptibility to insect attack.—It has been shown that there is a correlation between the salicin content of willows and liability to attack by the willow beetle (*Phyllodecta vitellinae*). Possible correlations are being examined for other willow insect pests.

Control of the larvae of Otiorrhynchus sulcatus attacking greenhouse plants.—The root feeding larvae were not killed by dipping pots of infested cyclamen into pyrethrum emulsions. Paradichlorobenzene incorporated in the potting soil provided a high measure of control but harmed the roots of the plants.

The spreading and adhesive properties of colloidal lead arsenate on willow foliage.—One of the principal reasons for the failure of lead arsenate to provide efficient control of willow beetles has been due to uneven spreading of the insecticide on the foliage. Colloidal lead arsenate, used in conjunction with the spreader Agral I, gave an excellent cover of the leaves of a large selection of willow varieties and adhered for a long period (1).

The control of the blow-fly of bacon.—Experiments were carried out in the laboratory and in a bacon factory to determine the efficiency of pyrethrum preparations as repellents to blow-flies. Preliminary experiments showed that the active principles of pyrethrum in a vegetable oil gave promising results.

Repellents to insects attacking man.—A number of repellents were investigated and a preparation consisting of an extract of pyrethrins incorporated in vegetable oils was the most efficient repellent to flies, mosquitos, midges, harvest bugs, etc.

Titles of papers issued during the year.

1. HUTCHINSON, H. P., and KEARNS, H. G. H.: The control of *Phyllodecta vitellinae* L. A major pest of willows. *Ann. Rep. Long Ashton Res. Stn.*, 124, 1930.
2. ——— ———: The control of *Galerucella lineola*. A major pest of willows. *Ibid.*, **124**, 1930.
3. KEARNS, H. G. H.: The larval and pupal anatomy of *Stenomalus micans* (*Pteromalidae*), a chalcid endo-parasite of the gout-fly of barley (*Chlorops taeniopus* Meig.), with some details of the life history of the summer generations. *Parasitol.* **23**, 3, 1931.
4. ———: Pyrethrum insecticides. *N.F.U. Record* (*Worcs.*), July, 1931.
5. WALTON, C. L., and KEARNS, H. G. H.: Carabid beetles as strawberry pests in the Cheddar districts. *J. Min. Agric.*, **38**, 4, 373, 1931.

63. CAMBRIDGE UNIVERSITY.

The control of apple capsid bug (Plesiocoris rugicollis) by winter spraying.—Experiments were carried out at West Walton, near Wisbech, on the value of mineral oil emulsions and tar oil emulsions on four different varieties. The best results were obtained by an application of Long Ashton wash followed about a month later by an application of mineral oil emulsion. The Long Ashton wash and a mixture of this and mineral oil emulsion caused serious damage to two of the varieties. These experiments have materially assisted in drawing up a suitable spraying programme.

The effect of the time of winter spraying on capsid control.—This was carried out at Over, Cambs., in conjunction with Mr. K. D. Cramp, the Assistant County Organiser. Spraying at the end of February and the middle of March with Long Ashton wash gave better results than spraying early in February, but none of the results was up to expectations (2).

The control of capsid bugs (Plesiocoris rugicollis and Lygus pabulinus) on black currants.—These experiments were carried out at Aldreth, Cambs. A home-made emulsion of high boiling neutral tar oils and mineral oil emulsion reduced the shoot infection from 100 per cent. to 24–50 per cent. The emulsion of the mineral oil alone caused no reduction of infections. None of the sprayings increased the crop.

The control of raspberry beetle (Byturus tomentosus).—These experiments were carried out at Haddenham, Isle of Ely. Good results were obtained from three sprayings of a proprietary wash containing pyrethrum and by another containing derris. The latter is much cheaper than the former and seems likely to give satisfactory commercial results.

The control of flea beetle on brassicae.—These experiments were carried out at three centres in Bedfordshire in co-operation with Mr. J. W. Dallas, the County Organiser. They show the importance of the time of application. The best results were obtained by the use of nicotine dusts.

Titles of papers issued during the year.

1. PETHERBRIDGE, F. R., and HEY, G. L.: The control of the common green capsid bug on red currants. *J. Min. Agric.*, **37**, 12, 1,185, 1931.
2. ——— ———: Winter spraying to control the apple capsid bug. *Ibid.*, **37**, 11, 1,078, 1931.
3. THOMAS, I.: The structure and life history of *Sciara nitidicollis* Meig. (*diptera*). *Proc. Zool. Soc. Lond.*, 65, Dec., 1930.

64. CARDIFF: UNIVERSITY COLLEGE OF SOUTH WALES.

Winter spraying trials.—Trials were instituted at several centres with tar-distillate sprays, with the addition of a sulphur preparation, with the object of controlling fruit tree red spider as well as aphis and winter moth eggs. Three other sprays not in common use in the area were also tried experimentally, namely :—

(*a*) Long Ashton wash—both modified and two solution ;

(*b*) winter " solol " ; and

(*c*) " Sulsol "—against red spider.

Potato eelworm (*Heterodera schachtii*).—Further tests were carried out of drained creosote salts for the control of potato eelworm. The chemical gave no results of commercial value.

Control of a watercress pest (*Phaedon cochleariae*).—Three methods were tried :—

(*a*) a derris preparation, which gave very satisfactory results ;

(*b*) a pyrethrum wash ; and

(*c*) derris used as a powder.

Big-bud mite on black currant.—Further investigation was made of a local highly resistant variety belonging to the French (Merveille de la Gironde) group. Tests of this variety are also to be made at East Malling.

Greenhouse white fly.—The parasite (*Encarsia formosa*) was kept going over the winter at three centres from which numerous growers in the area were supplied with parasites.

Warble fly control.—Tests of derris-soft soap wash were made at eleven centres.

Root fly control.—The use of naphthalene as a deterrent against the various root flies was clearly shown.

Title of paper issued during the year.

1. THOMPSON, H. W.: Notes on unusual pest occurrences in 1930. *Welsh J. Agric.*, 7.

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65. HARPER ADAMS AGRICULTURAL COLLEGE.

Control of cabbage root fly.—A comparative study was made of the effect of certain mechanical and chemical treatments as means of control of the cabbage root fly. Almost complete control has been given at all centres by both mercuric chloride solution and " drained creosote salts."

Life history, bionomics and control of the beet pigmy beetle (*Atomaria sp.*).—Studies into life history and bionomics are still incomplete, but very efficient control has been effected by steeping the seed of sugar beet and mangold prior to sowing in a solution of phenol and magnesium sulphate.

Bionomics and control of a nematode (Heterodera schachtii) of peas and beans.—It is felt that much further research is urgently needed to discover the part played by this nematode in the failure of peas in the Province, as in almost all cases examined during the past three years this parasite has been present.

Carrot and onion flies.—Experiments were carried out on the prevention of carrot and onion flies attacks by the use of naphthalene and other chemotropic substances ; the bionomics and life histories of these pests are also being studied. These investigations have already yielded some interesting results and are likely to prove of considerable economic significance.

Winter washes.—Extensive trials were made of various winter washes against the overwintering eggs of red spider, capsid bug and other orchard pests. This work is proceeding and promising some interesting results.

66. LEEDS UNIVERSITY.

Mangold fly.—The study of the habits of the fly, particularly in its winged stage, was much interfered with by the weather. Umbelliferous plants growing around the farm fields were cut down early in the season with the idea of depriving the flies of their natural source of food. From the experience gained this year it would seem that the ravages of the mangold fly can be checked without serious outlay of cost or labour.

Black aphis.—After wintering on docks, the aphids were found at the end of June on mangolds and sugar beet. During the following weeks they threatened to spread, but apparently their powers of increase were checked by the unfavourable weather. At the end of June and beginning of August they began to disappear from the crops. A few were observed in September on thistles.

Celery fly.—The fly was scarce this year, not only on the celery itself, but also on hogweed, its wild host. Local allotment holders, when the second brood appeared in September, were induced to destroy them on a fairly large scale. It is hoped to continue this work next summer and to begin the campaign by attacking the first brood of larvae.

Carrot fly.—A very serious outbreak occurred in the Pocklington district. Observations were made on the local features of the attack, and a field trap was devised to catch the flies of the second brood whilst they are frequenting the carrot foliage. There has not been, however, sufficient time to test its value.

Potato eelworm.—The potato plants grown in 1931 on the mustard plots of the previous year gave a somewhat better yield than the controls. Box experiments made to test the effect of treating the soil with corrosive sublimate at the rate of 1/250 gave encouraging results, and it is hoped to repeat these experiments next year.

Tomatoes which were grown in eelworm infected soil were found to be damaged by the potato eelworm *Heterodera schachtii*, the same eelworm as that which attacks the potato. This observation seems to show that tomatoes are not completely resistant to *Heterodera schachtii*.

An eelworm attacking sweet peas.—The eelworm which Dr. Goodey identifies as *Tylenchus pratensis* was observed in Yorkshire for the first time. Dr. Goodey reports that this species " is now recognised as an important and widespread root parasite."

67. MANCHESTER UNIVERSITY.

Control of red spider on apple trees.—The investigation on the use of washes applied during the dormant season for the control of red spider in fruit plantations has been continued. Mineral oil emulsions have effected up to 90 per cent. control of red spider but have not given satisfactory control of the other major pests of fruit trees. A mixed wash of tar-oil and mineral oil, 7 per cent. of each, has given fairly good control of red spider and the usual insect pests. Supplementary applications of lime sulphur during the summer for the control of apple scab have checked effectively the subsequent development of red spider.

Control of cabbage root maggot.—Treatment with corrosive sublimate solution, 1 : 1200, has again given satisfactory control of root maggot, and a dressing of calcium cyanamide has been found to assist recovery from attack and ensure a reasonably good yield on land infested with *Plasmodiophora brassicae.* A full account of the investigations carried out the previous season has been published during the year (3).

Investigations on " potato sickness."—Experiments on soil treatment have continued and the value of calcium cyanamide is again apparent, though the effects of the wet season have tended to mask the response of the plants to the treatment.

Studies on the biology of sawflies.—Further larval studies on the sawflies infesting currants and gooseberries have shown that larval growth, as indicated by the width of the head or the width of the frons in successive instars, follows a regular geometrical progression. This fact is important in biological studies and precludes the possibility of an instar being overlooked. The growth ratio of the larvae of *Pteronus ribesii, Pteronus leucotrochus* and *Pristiphora pallipes* varies from about 1·3 to 1·4 approximately (4).

Insect injury to basket willows in the North West Province.—A survey is in progress of the various insects associated with basket willows and observations are being made on the influence of cultural operations on the insects usually occurring as pests.

The large willow aphis, *Melanoxantherum salicis*, has been found to live continuously from April to December on *Salix viminalis*, and so far the species has not been observed on poplar, to which it was formerly thought to migrate in summer. The allied species, *M. flocculosum*, has also been observed during 1931. Pests of outstanding importance locally are the larvae of *Depressaria contermin ella* and the various midges.

Investigations on the control of slugs.—The subject of the ecology and control of slugs has been under investigation since 1926. The study of local factors of soil and climate in the North Western Province has shown that these play an important part in maintaining slug prevalence, and together with local practices in agriculture and horticulture ensure favourable conditions for slug development (5). Direct control by trapping has been found to be quite inadequate and the use of slug killing agents is by no means satisfactory. The best results have followed the use of repellents such as corrosive sublimate, creosote and naphthalene, and modification of local practices has been recommended.

Pest control in agricultural practice.—A survey of pest control under ordinary farm and market garden conditions has shown (2) that for the most part growers have no equipment to deal with epidemic outbreaks and this indicates that pest control is not yet regarded as a routine operation. Much valuable time is lost in dealing with serious outbreaks in rural areas because of the difficulty of securing supplies of insecticidal and fungicidal materials. Supplies have usually to come from London and may take a week or longer in transit.

Titles of papers issued during the year.

1. Miles, H. W. : The fluted scale. *Icerya purchasi* Mask. *N.W. Nat.*, **5**, 4, 229, 1930.
2. ———— : Equipment for pest control. *Agric. Prog.*, **8**, 129, 1931.
3. ———— : The control of cabbage root fly. *J. Min. Agric.*, **37**, 12, 1,227, 1931.
4. ———— : Growth in larvae of *Tenthredinidae*. *J. of Expt. Biol.*, **8**, 4, 355, 1931.
5. Miles, H. W., Wood, J., and Thomas, I. : The ecology and control of slugs. *Ann. Appl. Biol.*, **18**, 3, 370, 1931.

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68. MIDLAND AGRICULTURAL COLLEGE.

Carrot fly control.—Experiments on the control of carrot fly, using different grades of naphthalene, have been repeated successfully under garden conditions. During this year large plots have been arranged on three farms in Lindsey in important carrot growing centres. The results have not been successful. This is possibly due to the more open nature of the field compared with the garden, causing too rapid evaporation of the naphthalene.

Field experiments against this pest when attacking celery have also been inconclusive this season. Further tests on both crops are to be made.

Wireworms.—Field experiments have been made in Lindsey against this pest, using dressings which have shown good results in pots. The results are not yet to hand.

Chafer attack on grassland.—This pest has become very serious over a large area in Nottinghamshire, and attempts are being made to control the insect by dressings and by mechanical operations. The latter, at present, offer the greater prospect of success, although rolling appears to be useless.

Cheese mites.—A large number of substances have been tested for use in killing these pests. Although carbon disulphide is a successful fumigant it is so dangerous to use that it is felt desirable to make this investigation. Sulphur dioxide and ammonia are now being tried on a commercial scale.

Weevil attack on strawberries.—Experiments are being made to control the attack of *Otiorrhynchus picipes* on strawberries in Lindsey.

Carabid beetle attacking sugar beet and mangolds.—Experiments have been made on the control of the beetle *Pterostichus vulgaris* which has caused considerable damage to sugar beet and mangold crops in various parts of this province.

Calandra granaria.—Experiments have been made to eradicate this insect from farm buildings and cottages in Nottinghamshire.

Carrot aphis (*Cavariella Capreæ*).—A severe outbreak of this pest occurred in Lindsey. Spraying tests with pyrethrum gave complete control. Parasitic and predacious insects produced complete control on other farms not sprayed.

Economic ornithology.—Since the completion of the survey of rooks in the province work has been continued on their feeding habits. Experiments are in progress to control larks, which regularly attack wheat in certain localities.

Insects and climate.—Phenological data have been taken as usual and the study of the direct effects of rain on insects has been continued (1).

Title of paper issued during the year.

1. Roebuck, A.: Influence of weather on insects, especially rainfall. *Min. Agric. Meteor. Conf. Rep.*, 1930.

69. NEWCASTLE : ARMSTRONG COLLEGE, DURHAM UNIVERSITY.

Trials with various washes against capsid bugs on black currants.—These trials were carried out in a plantation of 500 bushes in Cumberland, the substances used being activol nicotine, activol pyrethrum, "Solol" and activol derris. Figures obtained representing the percentage of kill for the various washes showed that derris was the most efficient, followed by nicotine and pyradol, "Solol" being practically useless against the pest.

Trials against wood-lice (*Oniscidae*) *in a cucumber house.*—Bran and Paris Green had been used with unsatisfactory results in a house 150 ft. by 20 ft. in which the plant roots were being attacked by large numbers of wood-lice. It was decided to test the effects, on plants and pest, of carbon disulphide, "Pysect," formalin and naphthalene on measured lengths in the rows.

Though the other substances were found to kill the pests if brought into contact with them, the most practically useful substance, in the grower's opinion, was naphthalene, by its action in repelling the wood-lice.

Title of paper issued during the year.

1. GRAY, R. A. H.: The diamond back moth (*Plutella maculipennis*) during the years 1914-1929. *J.R.H.S.*, **61**, 1, 1931.

70. OXFORD UNIVERSITY.

Breeding of oats resistant to frit fly.—The work on the breeding of oat strains resistant to the attack of frit fly has been continued with the aid of a special grant from the Development Fund. The work was hampered by the abnormal weather conditions that prevailed during the spring and summer. Hybridisation was difficult to effect, and the grain in the experimental cages ripened unsatisfactorily. The cold spring, as was expected, caused fly infestation to be exceptionally severe, standard susceptible varieties suffering losses of the order of 80 per cent., and standard resistant varieties 50 per cent. There was also a wide and possibly abnormal variation in the extent of the attack, as measured by the standard varieties. Variations seem to have been caused by very slight differences in local environment, and no completely satisfactory explanation has been discovered. Generally speaking, the resistance of previously selected hybrid strains was maintained; one family of four lines gave a mean loss as low as 38 per cent., with a range of from 30 per cent. to 44 per cent. A large amount of second and third generation material was grown on. Further crosses have been planned for next season.

71. READING UNIVERSITY.

Narcissus fly (*Merodon equestris*).—Work on this pest has been continuing for a number of years, and during the latter stages was aided by a special research grant from the Ministry. The work has been concluded this autumn and the full results will shortly be published. Briefly, the detailed life history has been worked out, and new control measures suggested. The most satisfactory of these would appear to be the use of a poison bait spray against the adult flies, and an account of this aspect of the work has been published (1).

Stem and bulb eelworm (*Tylenchus dipsaci*).—The studies of biologic strains is being continued. The work so far has been mainly in relation to the occurrence of the eelworm on weeds and narcissus. It may, however, prove of considerable use when a widespread outbreak of the pest again occurs on oat, which may be expected within the course of the next few seasons. A publication (2) has been made during the year in which the significance of the occurrence of biologic strains in *T. dipsaci* is discussed and reference made to previous work on the subject. The technique by which the nematode may regularly be induced to set up an infestation in a favoured host plant is described, as is its application to the experiments made. Experimental results obtained when fourteen strains of the nematode, of known history, are given facilities for entering alien host plants are presented in detail. The conclusions arrived at are that biologic strains of *T. dipsaci* occur, but that these strains are in some cases able to attack more than one host plant. Further, some affinity appears to exist between strains occurring in the narcissus and in the common plantains. The practical application of our knowledge, in the event of a crop being attacked by the nematode, is discussed.

Yellow stripe in narcissus.—Experiments are being continued with a view to determining the cause of the spread of this trouble. Preliminary experiments last year suggested that thrips may be associated with the spread, and it is hoped to confirm definitely, or refute, this possibility next year.

Strawberry investigations.—Special attention is being paid to the possibilities of effecting improvements in strawberries by means of subjecting runners to the hot water treatment prior to planting. On an experimental scale strawberries are found to withstand a temperature of 110° F. for from 20 to 30 minutes, all pests appear to be killed, and the plants subsequently make very satisfactory growth.

Titles of papers issued during the year.

1. Hodson, W. E. H.: A new method of preventing attacks of bulb flies in narcissus. *J. Min. Agric.*, **37**, 1, 54, 1931.
2. ——— : The stem and bulb eelworm, *Tylenchus dipsaci* (Kuhn) Bastian. A further contribution to our knowledge of the biologic strains of the nematode. *Ann. Appl. Biol.*, **18**, 1, 83, 1931.

3. Hodson, W. E. H. : Seventh annual report of the Department of Plant Pathology. *Seale-Hayne Coll. Pamphlet No.* 36, 36 pages. Abstracted in *Rev. Appl. Entom.*, **19**, series A, 6, 373, 1931.
4. ———— : A comparison of the immature stages of *Eumerus tuberculatus*, Rond., and *Syritta pipiens*, Linn. (Syrphidae). *Bull. Entom. Res.*, **22**, 1, 1931.

72. SEALE-HAYNE AGRICULTURAL COLLEGE.

Pyrethrum.—Seed was sown and an excellent supply of plants was raised. Owing to various difficulties it was not found possible to carry out the planting, and the work has had to remain in abeyance for the present year. For reasons of economy this work may not be continued.

Stem and bulb eelworm (*Tylenchus dipsaci*).—Investigations are in progress on the question of hot water treatment and its relation to both eelworm and bulb, in all its aspects (3).

The vine weevil (*Otiorrhynchus sulcatus*).—The study of this pest continues and considerable success has attended experimental trapping of adults and poisoning larvae.

Bulb flies.—A review of our knowledge of *Merodon equestris* will shortly be completed and published. During the summer months an intensive spraying campaign, using the newly devised poison bait, has been conducted in Devon, Cornwall, Berkshire and Middlesex. Results are not all to hand, but those which are show great promise.

Strawberry failures.—A series of hot water treatments of strawberry plants is being carried out with a view to the control of strawberry mite (*Tarsonemus fragariae*) and other pests. It is hoped also to obtain by this means strawberry plants free of eelworm (*Aphelenchus fragariae*), in order to gain further information as to the importance, or otherwise, of this almost invariable inhabitant of the strawberry plant.

Titles of papers issued during the year.

1. Hodson, W. E. H., and Beaumont, A. : Seventh annual report of the Department of Plant Pathology. *Seale-Hayne Coll. Pamph.*, No. 36. 36 pages. *Abstracted in Rev. Appl. Entom.*, **19**, Series A, 6, 373, 1931,
2. Hodson, W. E. H. : A new method of preventing attacks of bulb flies in narcissus. *J. Min. Agric.*, **37**, 1, 54, 1931. *Abstracted in Rev. Appl. Entom.*, **19**, Series A, 6, 374, 1931.
3. ———— : The stem and bulb eelworm, *Tylenchus dipsaci* (Kuhn) Bastian. A further contribution to our knowledge of the biologic strains of the nematode. *Ann. Appl. Biol.*, **18**, 1, 83, 1931.

73. WYE : SOUTH-EASTERN AGRICULTURAL COLLEGE, LONDON UNIVERSITY.

Continuation of the investigation into the bionomics and control of the strawberry bud weevil (*Anthonomous rubi*).—The life-history has been worked out, numerous wild host plants discovered and parasites reared and identified. Control experiments were carried out in Hants. and E. Sussex.

The crane flies (*Tipulidae*) *of economic importance.*—Larvae have been collected where they were found doing damage to crops, the adults reared and identified.

Fruit tree winter washes.—In co-operation with the Chemical Research Department, fruit tree winter washes have been prepared in order to test the ovicidal value of tar and petroleum oils against the eggs of various insects, particularly the capsid bugs, *Plesiocoris rugicollis* and *Lygus pabulinus*, on apples and currants. Laboratory and field trials have been carried out with these washes. Further trials with proprietary washes for the same purpose have been continued (**4**).

The half acre plot of pyrethrum has been cultivated and harvested. Data relating to various methods of harvesting have been obtained.

Titles of papers issued during the year.

1. JARY, S. G. : A note on the strawberry and raspberry bud weevil (*Anthonomous rubi* Herbst). *J. S.E. Agric. Coll.*, **28**, 147, 1931.
2. ——— : Some observations on winter moth caterpillar attacks on fruit trees in 1929-1930. *Ibid.*, **28**, 137, 1931.
3. AUSTIN, M. D. : Capsid pests of chrysanthemums : A preliminary note. *Market Grower and Salesman*, **8**, 28, 14, 1931.
4. ——— : Control of apple capsid. *J. Min. Agric.*, **38**, 2, 154, 1931.
5. ——— : A contribution to the biology of the apple capsid (*Plesiocoris rugicollis* Fall.) and the common green capsid (*Lygus pabulinus* Linn.) *J. S.E. Agric. Coll.*, **28**, 153, 1931, 8 figs.
6. ——— : Observations on the hibernation and spring oviposition of *Lygus pratensis* Linn. *Ent. Mon. Mag.*, **67**, 149. 1931, 3 figs.
7. ——— : Hemipterous pests of chrysanthemums. *Fruit-grower*, **72**, 49 and 83, 1931.

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74. ABERDEEN : NORTH OF SCOTLAND COLLEGE OF AGRICULTURE.

Acarine disease.—This disease has been reported from 12 counties in Scotland, 16 in England, 2 in Wales, and 2 in North Ireland. The adverse weather of the season has in many localities restricted the foraging activities of the bees, so that numbers were confined to their hives, and this seems to have resulted in an extra high percentage of acarine infection during the later part of the year. Nosema, amœbic and fungus infections seem also to have been favoured by the weather (4).

Frow's mixture (2 parts nitrobenzene, 2 parts petrol, 1 part safrole) for the treatment of acarine disease has proved very satisfactory in a number of cases examined by the Department. The benefit of Frow's mixture lies in proper dosage, when it is able to kill the mites of all stages inside the tracheae of living bees. Strictly speaking, it does not " cure " diseased bees, but it kills the mites inside them so that they do not pass on the infection to other bees. The recovery of the colony depends on good beekeeping, which provides for the establishment of a strong colony as soon as possible after the treatment (3, 5, 6).

General entomology.—A fair number of insects and related pests have been examined and reported upon within the College area. These include cabbage root fly, wire worms, wasps, white fly, earwigs, millipedes and big bud mites.

Titles of papers issued during the year.

1. Morison, G. D.: New Thysanoptera from South Australia. *Bull. Entom Res.*, **21**, 449, 1930.
2. ————: Larva of *Dermestes vulpinus* F. does not feed on wood. *Entom. Mon. Mag.*, **67**, 92, 1931.
3. ——Notes on Acarine Disease of the honey-bee. *Bee World*, **12**, 40, 1931.
4. ——: Amœbic disease of bees in Great Britain. *Ibid.*, **12**, 56, 1931.
5. ——: Observations on the numbers of mites, *Acarapis woodi* (Rennie) found in the tracheae of the honey-bee. *Ibid.*, **12**, 74, 1931.
6. ————: Comments on chemical treatment of acarine disease. *Ibid.*, **12**, 89, 1931.
7. ————: A new Thripid (*Thysanoptera*) from South Australia. *Bull. Entom. Res.*, **22**, 245, 1931.
8. ————: The muscles of the adult honey-bee. *Bee Kingdom* (*Cairo*), **2**, 125, 1931.

75. EDINBURGH AND EAST OF SCOTLAND COLLEGE OF AGRICULTURE.

The most important pest of the district is the slug. The species commonest in the potato crops appear to be *Agriolimax agrestis* and *Arion circumspectus*. Experiments were made as to the possibility of control with sodium fluosilicate, but they were not successful.

The presence of a large number of insect cocoons among newly threshed oats was reported on more than one occasion by growers believing them to be injurious. In spite of many efforts, none of these has been bred, but it is practically certain that they are the cocoons of a parasitic ichneumon fly of the family *Ophionidae*, and presumably parasitic on noctuid caterpillars, which have been brought from the field into the stack in the autumn.

A number of enquiries with regard to greenhouse insects included several about white fly of tomatoes, which appears to be widely distributed in the district. One or two growers wished to try the *Encarsia* parasite. This had been introduced into Edinburgh a year or two previously by the University Agricultural Entomology Department. It had died out in the greenhouses where it had been liberated.

In November, 1930, a small infestation of azaleas by a white fly new to Britain was discovered at Cramond. The azaleas had recently been imported from Belgium. The white fly (*Aleurodes azaleae*) was previously known and originally described from specimens intercepted in U.S.A. on azaleas also from Belgium. The infestation was small and the majority of specimens were already dead when discovered.

A considerable amount of work has been done on preparing a representative collection of British pests and their life histories. Cabinets have been purchased and a good start on the essential work has been made.

Earwigs seem to have been unusually common as domestic pests during the past year, particularly in districts near the sea.

N.

MYCOLOGY
and
BOTANY.

76. ABERYSTWYTH : UNIVERSITY COLLEGE OF WALES.

Swede disease.—Variety trials were undertaken at 25 centres to test the resistance to " finger-and-toe " of different varieties and more particularly varieties which are reputed to be highly resistant on the continent.

Control of covered smut of barley.—This experiment was continued during the present season. Various methods were tested but copper sulphate, 2½ per cent., and formalin, 1 : 420, treatment gave the most satisfactory results. It is intended to continue these trials over a number of years.

Onion mildew.—Various plots were laid down in the Experimental Gardens with a view to testing various chemicals. The new spray mixture resin-sulphur gave fairly satisfactory results. Its spreading qualities on onion leaf was superior to all other chemicals tested.

Clover mildew.—Under greenhouse conditions this disease is very troublesome at the Welsh Plant Breeding Station. The effect of the disease is to defoliate the plants prematurely, resulting in badly filled seed. Occasional dusting with a special proprietary brand of sulphur gave promising results. These experiments will be continued on a larger scale during the coming season.

The use of mercuric chloride against " finger-and-toe " in brassicae.—One application at planting out of 1 : 2,000 failed to control the disease absolutely in savoys and cabbages. The growth on the treated plots was, however, far superior to untreated plots.

Title of paper issued during the year.

1. Davies, D. W. : Grey speck disease of oats. *Welsh J. Agric.*, **7**, 1931.

77. BANGOR : UNIVERSITY COLLEGE OF NORTH WALES.

Virus diseases of potatoes.—A study of the virus diseases of potatoes—and, in particular, leaf roll—continues to form the main line of investigation. An account of these diseases in relation to commercial seed potato production, based on several years' experience in this work in North Wales, has been written conjointly by the Adviser and Mr. J. F. Currie, and is now in the press (4). With this is included a study of the aphis population at the seed potato centres, by the Adviser in Entomology (5). The problem of immaturity *qua* immaturity in seed potatoes has been attacked again from a different angle. It has been shown that the degree of " greening " and " sprouting " depends solely on length of storage and not on the degree of immaturity when lifted. The health and vigour of the resulting plants were only maintained in equally immature seed when the immaturity was obtained by early lifting. Immaturity conveyed no advantage apart from reduced liability to virus infection. In critical glass-house work in which various common soil animals were introduced separately and collectively into pots carrying both healthy and infected plants, no evidence of soil transmission of leaf roll was obtained. Similar work with three species of aphis showed that *Myzus circumflexus* and *Myzus persicæ* are both efficient vectors of leaf roll, while the possibility still remains open that *Macrosiphum gei* may also occasionally act as a vector. This work has been published (2). A study of the metabolic disturbances induced in a potato by leaf roll infection has been in progress for a considerable time. The respiration of healthy and infected plants, under both aerobic and anaerobic conditions, has been ascertained at various stages in the life-cycle. The respiration of the healthy tuber falls as maturity advances and again rises with the development of sprouts. In the growing plant the respiration is many times that of the sprouting tuber. The infected tuber respires at a greater rate than the healthy tuber when immature, but falls to a lower level with complete maturity, and fails to regain the lead until green leaves have formed. The foliage of the infected plant, however, respires at a higher rate even than the healthy foliage. Respiration in nitrogen is not affected by the presence of the leaf roll virus. The work is being continued.

Titles of papers issued during the year.

1. Whitehead, T.: Field trials with Golden Wonder and King Edward VII potatoes. *Scott. J. Agric.*, **14**, 2, 1931.
2. ————: On the transmission of potato leaf-roll by aphides. *Ann. Appl. Biol.*, **18**, 3, 1931.
3. Whitehead, T., and Currie, J. F.: The susceptibility of certain potato varieties to leaf-roll and mosaic infection. *Ibid.*, **18**, 4, 1931.
4. ————: Virus diseases in relation to commercial seed potato production. (In the press.)
5. Davies, W. M.: A study of the aphis population at certain farms. (In the press.)

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78. BRISTOL UNIVERSITY.

Fruit diseases.—Work was continued on the die-backs of apple trees associated with *Cytospora* sp. No positive results were obtained from inoculations of the fungus on healthy plants.

A prevalent fruit rot of apples and pears due to *Phytophthora syringae* was described (1).

Strawberry leaf-spots and fruit rots were under investigation, notably a " hard rot " common on fruit of the variety " Paxton " (2).

Vegetable diseases.—Considerable progress was made with work on vegetable diseases (3). The chief diseases investigated were asparagus root rots, "halo blight" of dwarf beans, "foot rots" of broad and runner beans, miscellaneous lettuce diseases, "white tip" of leeks, mint rust, parsnip "canker," pea pod spots and foot rots, marrow mosaic and mildew, and potato "sickness."

Articles were published on the control of "white tip" of leeks (4), a new leaf spot of lettuce, caused by *Pleospora herbarum* (5), and pea "sickness," associated with *Heterodera schachtii* and certain fungi (6).

Rusts of willows.—The rusts of basket willows which occur in Somerset were identified as *Melampsora amygdalinae* (on *Salix triandra*) and *M. larici-epitea* (on *S. viminalis*) and important information was obtained on the biology of the former.

Hop diseases.—Observations were made on hop diseases, especially downy mildew, and "nettlehead" and "split-leaf," two important virus diseases (7, 8).

Titles of papers issued during the year,

1. OGILVIE, L. : A fruit rot of apples and pears due to a variety of *Phytophthora syringae*. *Ann. Rep. Long Ashton Res. Stn.*, 147, 1930.
2. ———— : Some important strawberry diseases. *Herefordshire Review of Agric.* (*N.F.U. Record*), Sept., 1931.
3. OGILVIE, L., and MULLIGAN, B. O. : Progress report on vegetable diseases. *Ann. Rep. Long Ashton Res. Stn.*, 127, 1930.
4. ———— ———— : White tip disease of leeks. *Gard. Chron.*, **89**, 360, 1931.
5. ———— ———— : A leaf spot disease of lettuce due to *Pleospora herbarium*. *Ibid.*, **89**, 35, 1931.
6. ———— ———— : "Pea sickness," an important disease of field peas. *Ibid.*, **90**, 122, 1931.
7. OGILVIE, L. : Diseases of hops in Herefordshire. *Herefordshire Review* (*N.F.U. Record*), Aug., 1931.
8. ———— : Diseases of hops in Worcestershire. *N.F.U. Record* (*Worcs. Section*), Aug., 1931.

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79. CAMBRIDGE UNIVERSITY.

Apple and pear scab.—As would be expected in a wet spring and summer, apple and pear scab were exceptionally severe. This is probably the worst scab year since the advisory service started. Spraying gave good results in most cases, but in some orchards it gave a rather poor control. One grower who did three pre-blossom and two post-blossom sprayings obtained rather unsatisfactory results, whereas other growers in the same neighbourhood obtained good results. Dusting with proprietary sulphur dusts gave unsatisfactory results as compared with spraying, and most of the growers who used it this year have decided not to use it before blossoming time in the future.

In our experiments a proprietary sulphur dust containing Banks. colloidal sulphur 13·5 per cent., lead arsenate 10 per cent., sulphur (300 mesh) 76·5 per cent. gave a satisfactory control of scab, but reduced the crop. A proprietary copper dust used by a grower gave fairly good results on Bramleys in West Norfolk.

The control of pear scab.—These experiments were carried out at two centres in Huntingdonshire in co-operation with Mr. F. Tunnington, the County Organiser. No results were obtained as the crop failed at both centres.

Spraying versus dusting for the control of apple scab.—In these experiments, which have been carried on for three years on the same trees, both spraying and dusting gave a satisfactory control of scab, but the crop on the sprayed trees was bigger than that on the dusted trees, especially in the case of Lane's Prince Albert.

Titles of papers issued during the year.

1. Dillon-Weston, W. A. R.: Ineffective nature of iodine dust as a fungicide against *Tilletia caries*. *Phytopath.*, **20**, 753, 1930.
2. Dillon-Weston, W. A. R., and Halnan, E. T.: The fungicidal action of ultra-violet radiation. *Ibid.*, **20**, 959, 1930.

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80. CARDIFF: UNIVERSITY COLLEGE OF SOUTH WALES.

Sainfoin.—(*a*) Investigations on the persistency and habits of sainfoin lots of different origin, (*b*) study of the effect of milling the seeds on the germination and establishment in field plots, (*c*) saving of seed from a local strain, (*d*) propagation of plants by cuttings and layers, and (*e*) observation of field plots of common sainfoin in new localities, were in progress (1).

Lucerne.—The study of hardiness, persistency and disease resistance on twenty-three lots was continued.

Grasses.—Observations on strains of indigenous ryegrass, timothy and cocksfoot, from the Welsh Plant Breeding Station were made with special reference to habit and disease resistance in comparison with commercial strains.

Soya beans.—Two varieties were grown for observation.

" *Finger-and-toe.*"—(*a*) Trials were carried out of Danish swedes and Scottish turnips resistant to " finger-and-toe " on farms.

(*b*) A study was made of raising plants in seed bed treated with corrosive sublimate and watering in plants of brassicae when planting in contaminated ground.

Manganese deficiency.—The effect of applications of manganese sulphate on plots of oats in the field was studied.

Common scab of potatoes.—Small plots were laid out at Green Farm to test the control effect of (*a*) grass mowings and (*b*) flowers of sulphur dug into the soil, and of disinfecting the sets with (*c*) formaldehyde, and (*d*) corrosive sublimate solution.

Hay analysis.—Botanical analysis was made of hay from plots manured several years with the same manure at the Monmouthshire Agricultural Institution.

Title of paper issued during the year.

1. Rees, J.: Experiments on the depth and time of sowing of sainfoin. *Welsh J. Agric.*, **7**, 155, 1931.

81. HARPER ADAMS AGRICULTURAL COLLEGE.

Control of "finger-and-toe" disease.—Previous experiments (1) had shown that a 0·05 per cent. solution of mercuric chloride could generally be relied upon to give satisfactory control of "finger-and-toe," while mercurous chloride might also be of value. Further trials of these substances were therefore made and, in addition, experiments with sodium carbonate and with hydrated lime were conducted. Calcium cyanamide and nitro-chalk, having previously proved unsatisfactory, were not tested further. The experiments were carried out at ten different centres.

Results now available confirm the previous ones, and show that the best control is undoubtedly given by 0·05 per cent. mercuric chloride applied to the holes when planting. Mercurous chloride and sodium carbonate both proved unsatisfactory. A reasonable measure of control was obtained with hydrated lime when applied at the rate of 3 tons per acre. Smaller quantities, however, under the conditions of these experiments, failed to check the disease appreciably.

Arrangements have been made with other advisers for a co-operative investigation of the mercuric chloride treatment as now advocated.

Potato trials (virus diseases).—A comparative trial of Welsh and Scotch "seed" stocks was undertaken in co-operation with University College, Bangor.

Laboratory work.—Research work upon certain parasitic fungi is in progress.

The investigation of the fungus causing a leaf spot of turnips which was started some four years ago is still being continued. Single spore cultures have now been obtained from material collected in eight different localities in Britain and also from lesions on Chinese cabbage, affected leaves of which were obtained from the United States. These have been compared with cultures of *Cercospora bloxami* and *Cercosporella albo-maculans* supplied by the Baarm laboratory. Unfortunately all these forms remain obstinately sterile on artificial media so that a comparison of the spores from pure cultures has so far been impossible, and infection experiments have also been rendered unusually difficult. This year, however, positive infection of Chinese cabbage was secured with the British organism by using mycelial material from the cultures.

Further study has been made of the fungus *Coniothyrium tukelii* obtained from rose cankers. The perfect stage attributed to this fungus has, however, not yet been observed under cultural conditions. Three other organisms obtained from diseased rose stems are also under observation.

Title of paper issued during the year.

1. Preston, N. C.: The prevention of "finger-and-toe" (club root) in gardens and allotments. *J. Min. Agric.*, **38**, 3, 272, 1931.

82. LEEDS UNIVERSITY.

Raising of virus free stocks of potatoes in Yorkshire.—These stocks were transferred to another farm this year, and for some inexplicable reason there developed a considerable amount of virus disease. Samples grown at Ormskirk from the same stock of seed gave as healthy crops as the previous year.

Leaf spot of oats (*Helminthosporium avenae*).—An account of this work is now in the publisher's hands. Subsequent trials this year of seed treatment with a proprietary mercury compound and with formalin respectively gave excellent results. Germination was apparently accelerated by the former treatment.

Grey leaf of oats.—Extensive trials of soil and seed treatment with manganese sulphate and permanganate of potash have been carried out at several centres. The effect of rolling has also been tested.

Bracken disease.—No appreciable advance has been made in this work. Soil inoculations with various organisms isolated from Scottish material have been carried out, but no conclusions can be drawn from this year's growth of the plants. Attempts to transmit the disease by mixing diseased rhizomes with the soil in which healthy rhizomes have been planted have not, so far, been successful.

"*Finger-and-toe*" *disease.*—Experiments with water culture solutions have been started to ascertain whether a change in the basic ratio affects the infectivity of *Plasmodiophora brassicae*, i.e., to ascertain why lime acts as a deterrent to the disease.

Potato sickness.—Pot experiments in this their second year have shown striking results. Field experiments in which, among other things, the effect of a mustard crop ploughed in and of soil treatment with mercuric chloride have been tested, were continued.

Sprain or internal rust spot of potato.—An account of this work is now in the publisher's hands.

Foot rot of peas.—A comparison of this disease and its causative organism with that caused by *Ascochyta pinodella* in America has now been completed.

Anthracnose of begonia.—Inoculation experiments prove a species of *Colletotrichum* to be the cause of this disease.

Pink rot.—Control of this disease and variety tests have now been written up for publication.

A disease of seedling calceolarias.—This investigation has now been abandoned since there is reason to believe that the trouble is mainly cultural.

A rot of gloxinia.—This disease has recently caused great losses to commercial growers and an investigation of its nature is being started.

Title of paper issued during the year.

1. JONES, A. POWELL: The histogeny of potato scab. *Ann. Appl. Biol.*, **18**, 3, 313, 1931.

83. MANCHESTER UNIVERSITY.

Onion white rot (*Sclerotium cepivorum*).—After several years' tests, varieties possessing marked resistance to this disease have been found. Since these particular varieties lack other desirable market qualities, breeding work is being undertaken at the Vegetable Research Station, Cambridge.

Clubroot of brassicae (*Plasmodiophora brassicae*).—Further exhaustive tests with corrosive sublimate as a temporary control measure in the seedbed and field have fully confirmed the previous three years' findings. On a commercial scale, the method has proved successful and is being adopted (1).

Celery blight (*Septoria apii*).—The beneficial effects of seed and soil treatment with formaldehyde, followed by spraying with Bordeaux mixture, have been clearly established. The raising of clean seed stocks on a commercial scale is being carried out by two large firms.

Apple mildew (*Podosphaera leucotricha*).—A dressing of three hundredweights per acre sulphate of potash has been found to minimise greatly the severity of this disease. Two new types of spray applied in spring have yielded extremely promising results in the way of control of this malady.

Tomato stripe (*Bacillus lathyri*).—Experiments in sterilizing seed, as well as soil, have again given quite satisfactory results in the way of controlling this disease. Similar investigations on a larger scale are being carried out at the Cheshunt Experimental Station.

Tomato mildew (*Cladosporium fulvum*).—Three different liquid sprays were carefully and exhaustively compared. One proved very satisfactory as a preventive, but further improvements and experiments seem desirable before recommending it for general use by growers.

Lettuce mildew (*Bremia lactucae*).—Two varieties of indoor lettuce of Continental origin have been found to be immune to this disease and a third has proved highly resistant. Soil sterilization, improved cultural methods and properly balanced manuring have also effectively controlled it.

Rose stem canker (*Leptosphaeria coniothyrium*) *and blackspot* (*Diplocarpon rosae*).—Severe pruning in autumn coupled with better and more hygienic cultural methods, followed by periodical spraying, have proved successful as control measures under glass.

Tulip "fire" blight (*Botrytis tulipae*).—Spraying the young bulbs with a weak fungicide before and after introduction to heat for forcing has successfully checked the spread of this destructive disease under commercial conditions.

Title of paper issued during the year.

1. Smith, E. H.: The control of clubroot and root maggot of *Brassicae*. *Gard. Chron.*, **90**, 1931, 5 text figs.

84. MIDLAND AGRICULTURAL COLLEGE.

"Damping-off" and foot rot of tomatoes.—Further experiments were carried out on the control of this disease, which is responsible for serious losses to many tomato growers every year. "Cheshunt compound" has proved to be useless for controlling this disease. The treatment of the soil with formalin gave excellent results. A method of preventing the disease in older plants, in which the hole in the soil was filled with coarse sand instead of soil, was tried. The method was not completely successful as a few cases of the disease occurred. It has been observed that slow-growing and hardy plants are very resistant to this disease.

Mint rust.—An attempt to establish a clean bed of mint from one badly diseased with rust, by burning off the bed in October, was unsuccessful (2).

"Ring spot" of carnations.—Successful experiments were carried out on the control of this disease of carnations, which was spreading rapidly through some new and valuable varieties of carnations under glass. The disease was completely checked by (*a*) hand-picking those leaves so badly attacked that they were withered and brown, (*b*) ceasing overhead watering, and (*c*) spraying the plants thoroughly with hydrated lime Bordeaux mixture (4 : 6 : 40) to which soft soap had been added as a spreader.

Celery diseases.—Assistance has been given to a number of celery growers who are attempting to produce disease-free seed. A case of *Phoma* root rot in celery has been investigated. The seed used was not infected and the disease must have been caused by infection from the soil (1, 2, 3, 4).

Eradication of weeds in lawns.—Observations have been made on the use of a mixture of sand, sulphate of ammonia, and calcined sulphate of iron to eradicate weeds in lawns, bowling and golf greens. The treatment was very successful. For the eradication of broad-leaved weeds such as plantain and dandelion, creosote painted on the weeds with a brush effectively killed them, but caused brownish-black patches on which grass did not grow until at least 6 months after the treatment.

Titles of papers issued during the year.

1. Stirrup, H. H.: Investigations on celery diseases and their control. *Min. Agric. Bull. No.* 25., Feb., 1931.
2. ———: Contributions to *The Encyclopædia of Scientific Agriculture.* Baillière, Tindall and Cox. 2 vols. Sept., 1931.
3. ———: Celery blight and its prevention. *Bull. No.* 14. *Midland Agric. Coll.*, Sutton Bonington, June, 1931.
4. ———: Celery diseases. *The Horticulturist, Norfolk Agric. Cttee.*, July, 1931.

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85. NEWCASTLE: ARMSTRONG COLLEGE, DURHAM UNIVERSITY.

White-tip (blight) of leeks.—This disease is prevalent and destructive in the north of England. The causal organism, *Phytophthora Porri* (Foister), has been studied in relation to the occurrence of the disease, and control measures are under investigation.

Fusarium species on British cereals.—(*a*) *Gibberella Saubinetii* has been studied in its physiological and pathological aspects. Perithecia, produced freely under suitable, controlled conditions, are absent (or unknown) under field conditions in Britain. The fungus is parasitic on all cereals, causing seedling blight and foot rot as minor features and ear blight as the principal damage (1).

(*b*) *Fusarium Scirpi* Lamb. et Fautr. was isolated from four lots of cereals grown in the Eastern Counties. This organism as previously known is here designated variety *pallens*, and a phase hitherto unknown is described. A second variety, *nigrans*, is described and its relationship to the foregoing variety is elucidated. The pathogenicity of both varieties towards cereals has been investigated (paper in press).

Title of paper issued during the year.

1. Bennett, F. T.: Gibberella Saubinetii (Mont.) Sacc. on British cereals. Paper II. Physiological and pathological studies. *Ann. Appl. Biol.*, **18**, May, 1931.

86. OXFORD UNIVERSITY.

Apple mildew.—The work on apple mildew has been continued with the aid of a special grant. After extended trials, sulphur-casein suspension has been selected as the most satisfactory spray. Experiments on a field scale have shown that this treatment has reduced mildew by an amount varying from 50 to 86 per cent., depending on the previous condition of the trees, the strength of the solution, and the number of applications. The cost of the spray compares favourably with that of ordinary lime sulphur, and the sulphur-casein is free from the disadvantage of causing injury to the trees. Further sprayings were done in the past season, and the results will be collected in 1932. Some further work on the life-history of the fungus remains to be done, and the precise spray formula to be recommended in practice has yet to be determined.

Disease-resistant turnip variety.—A trial of the " Bruce " variety of turnip (which has been found by another investigator to be practically immune from " finger-and-toe " disease) was arranged in co-operation with Northampton Farm Institute. The " Bruce " variety remained practically unaffected, while an ordinary commercial variety of swedes, grown for comparison, was almost completely destroyed. A brief paper on this experiment is in the press (2).

Miscellaneous.—The work on *Cercospora* of beans has been prepared for publication (3) ; that on leaf spot in oats has been stopped, as the problem has been substantially cleared up by another investigator. Results of the investigation into sclerotial disease of winter beans, and into clover rot, are being prepared for publication. As regards freesia disease, it has been definitely established that the disease is carried by the corm, and can be readily conveyed by artificial inoculation. This work is being done in co-operation with the Advisory Officers of the Bristol Province.

Titles of papers issued during the year.

1. Woodward, R. C. : A home-made machine for dressing wheat with copper carbonate. *Farmer and Stockbreeder*, Nov., 1930.
2. ———— : A turnip resistant to " finger-and-toe." *J. Min. Agric.* (In the press.)
3. ———— : A note on *Cercospora Fabae* Fautr. on field beans—a new record in England. *Trans. Brit. Myc. Soc.* (In the press.)

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87. READING UNIVERSITY.

Dry rot and canker disease of swedes.—Observations and experiments have confirmed and extended the view that the disease may be present at every stage from the sowing of the seed to the folding of the roots, or the harvesting of the seed crop. Plants infected on the leaves very frequently become healthy individuals as old leaves drop off, and there has been no evidence of very extended spread from any one original centre of infection. In spite of the moist summer, no infected seed crop has been observed where the amount of the disease in the seed harvested is likely to be more than a maximum of 1 or 2 per cent., except where the plants were sprayed artificially with a spore suspension at the time of " podding." Further evidence has been obtained of the carrying over of the disease freely on *Brassica alba* occurring as a weed in swede fields, where it frequently passes under the name of " charlock," and also on dying plants of true charlock and runch. General infection of a swede crop may be brought about in this way, although, owing to the inconspicuous nature of the disease in the early stages, and on the weeds, the true source of infection is not noted by the casual observer.

A Phytophthora disease of tulips.—Previously the fungus *Phytophthora cryptogea* had been isolated, both at Harpenden and in Scotland, from specimens of " shanked " tulips, and thought to be the cause of the disease. The bulk of the work which has been done at this centre has been with a fungus best referred to as *Phyt. cryptogea* var. *Richardiae.* It has been shown to be the cause of a disease of tulips of which " shanking " is only one phase. The parasite may cause a root rot, and a complete rot of the flowering shoot before boxed tulips are taken indoors to be " forced." There may subsequently appear all stages of attack from the shoot rotting off before the flower bud is seen, through " shanking " of the flowering stem at the time the flower should be almost ready to cut, to the infection not showing up obviously at the base of the stem until after a flower of poor quality has been marketed. It has been shown for the first time that the disease may occur in outdoor beds of tulips. It is not thought that there is much possibility of the disease being carried over by the bulbs, if these are well cleaned before being planted.

Tests of fungicides on bunt in wheat, etc.—The Cotton Industry Research Association fungicide, " Shirlan," has not proved effective in the control of bunt even at a strength of 1·0 per cent. The killing power of " Shirlan " seems to be much less than its inhibiting power, while bacteria decompose it readily in low concentrations in the soil. Formaldehyde and copper carbonate dust retain their relative efficiencies, while " du Pont Granosan "(=the American " du Bay Ceresan ") has controlled bunt. " Du Pont Granosan " and the European " Ceresan " have considerably reduced the amount of *Phoma lingam* arising from badly infected swede seed, but no treatment applied cold has completely eliminated this disease without interfering seriously with germination.

Spotted wilt of tomatoes (the Australian virus disease) and *Bacterium medicaginis* var. *phaseolicola* on dwarf beans have been the most important of the diseases discovered for the first time in the Province.

88. SEALE-HAYNE AGRICULTURAL COLLEGE.

Potato blight.—Two plots of King Edward potatoes were observed in which the tubers had been planted at fortnightly intervals. The blight epidemic was rapid and severe, and the results showed that the progress of the attack was dependent on the position of the plants which exhibited the first signs of infection as well as on the time of planting.

Detailed observations were made of the weather (including the humidity continuously recorded) in relation to the appearance and progress of blight, and the great importance of periods of high relative humidity was established (1).

Control of black leg of mangolds.—Only two disinfection experiments were carried out and no control was obtained. Dressings of lime failed to control the disease. A much more extended investigation of the soils was carried out and it is clear that the amount of "available nitrogen" is important. The disease was too scarce to allow of any reliable generalisation to be made.

Narcissus diseases.—Experiments which cannot be summarised at this stage have been continued on *Ramularia vallisumbrosae, Stagonospora curtisii,* yellow stripe and root rot.

Hot water treatment of narcissus bulbs.—The effects on flowering and on the incidence of fungal diseases have been studied. No evidence was found that Fusarium rots are spread by the treatment.

Iris rust (*Heterosporium gracile*).—An investigation of the control of this disease has been begun.

Title of paper issued during the year.

1. BEAUMONT, A., and HODSON, W. E. H.: Seventh annual report of the Department of Plant Pathology for the year ending September 30th. 1930. *Seale-Hayne Coll. Pamph. No.* 36, 36 pp. Newton Abbot, 1931

89. WYE: SOUTH-EASTERN AGRICULTURAL COLLEGE, LONDON UNIVERSITY.

Downy mildew of the hop (*Pseudoperonospora humuli*).—The season of 1931 was the most disastrous hitherto known as regards the severity of downy mildew attacks on bine and cones. Many growers, however, by following the programme of control measures laid down at the Hopgrowers' Conference held at Wye College in January, 1931, secured full control of the disease and obtained healthy crops. Advances have been made in the technique of spraying and in spraying machinery. Experiments have shown that spraying hops when in burr with Bordeaux mixture does not interfere with the production of normally seeded cones, a fact which assists the grower in lengthening the time in which spraying can be carried out (1, 2).

Virus diseases of the hop.—Under a grant from the Ministry of Agriculture investigations concerning virus diseases of the hop have been continued.

Mosaic disease.—Grafting experiments were carried out in commercial gardens of the Fuggle variety and evidence obtained that this variety can " carry " the mosaic disease while showing no trace of it.

Chlorotic disease.—Investigations have shown that this disease, hitherto known on only one farm in Worcestershire, has occurred in three fresh localities. Experiments have shown that the characters of the mosaic and chlorotic diseases may be experimentally produced in one and the same plant, and that mosaic-carrier plants may be induced to show symptoms of mosaic disease some time after innoculation with the virus from chlorotic plants.

Apple scab.—In collaboration with the Chemical Research Department, large scale spraying experiments have been continued on the College Farm and a farm at Teynham, Kent (6). Plots of three commercial varieties of apples have been sprayed with various fungicides, and the extent to which the disease has been controlled has been ascertained by the hand-grading of the crops (several tons). A new fact in the life-history of the scab fungus has been discovered, viz., its occurrence on the scales of blossom-buds, on which it over-winters (3).

Experiments with fungicides.—In collaboration with the Chemical Research Department, biologically-controlled experiments have been carried out with the following substances :—vegetable oils, alcohols, phenols and salicylanilide.

Mushroom cultivation.—The methods employed in large-scale commercial mushroom growing in the area have been examined through the courtesy of growers, and the information gained has been used for the revision of the Ministry's Leaflet No. 276, which now appears as Bulletin No. 34. It was found that the majority of spawn used was imported. It was known as " pure-culture " and none of it was made in England. Experimental work on methods of production in the laboratory met with success and several horticulturists received instructions in the technique. As a result, home-produced pure-culture spawn was put on the market in 1931.

Titles of papers issued during the year.

1. SALMON, E. S., and WARE, W. M. : The downy mildew of the hop in 1930. *Jn. Inst. Brew.*, **37**, 24, 1931.
2. ———— ————: The hop downy mildew and its control. *S.E. Agric. Coll. Wye, Kent*, Feb., 1931, 15 pp., 11 figs.
3. ———— ————: A new fact in the life history of the apple scab fungus. *Gard. Chron.*, **89**, 437, 1931.
4. ———— ————: An unusual form of hop canker. *J. S. E. Agric. Coll.*, **28**, 62, 1931.
5. BAGENAL, N. B., GOODWIN, W., SALMON, E. S., and WARE, W. M. ; The control of apple scab. I. Bramley's seedling. *Ibid.*, **28**, 188, 1931.

6. Goodwin, W., Salmon, E. S., and Ware, W. M.: The control of apple scab. II. Allington Pippin and Newton Wonder. *Ibid.*, **28**, 196, 1931.
7. Ware, W. M.: A blossom wilt of lavender caused by *Botrytis cinerea*. *Ibid.*, **28**, 206, 1931.
8. ———: Immunisation of plants. A review of *L'Immunita nelle Piante* by D. Carbone and C. Arnaudi, 274 pp., Milan, 1930. *Nature*, **127**, 3192, 4, 1931.

90. EDINBURGH AND EAST OF SCOTLAND COLLEGE OF AGRICULTURE.

Hill pasture investigations.—Investigations upon the economic value and improvement of hill pastures were continued at Boghall Glen on lines similar to those indicated in previous reports. Various types of vegetation occurring in the Glen are under investigation and a general vegetation survey of the area was begun during the year.

Experiments with sown grasses and clovers and seeds mixtures.—These include the following:—

(*a*) Observation plots of various species and strains of herbage plants in pure culture at Boghall. These were sown in 1930 and have been under observation throughout the growing season.

(*b*) Small scale seeds mixture plots at Boghall designed mainly for the study of the competitive interactions of the various species sown and their suitability for inclusion in seeds mixtures. Botanical analyses of these plots have been made.

(*c*) Seeds mixtures for two years' ley, on a field scale at Boghall; two series, sown 1930 and 1931.

(*d*) Seeds mixtures for long duration leys at thirteen centres in the College Area (in co-operation with the County Staff). These were sown this year and are in the main designed to test various strains of rye grass and cocksfoot, although some other points are also under investigation.

Reclamation of tidal mud by means of rice grass (*Spartina Townsendii*).—Early in the year, attention was drawn by the County Organiser for Perthshire to the fact that a considerable area of tidal mud exists on the north bank of the Tay estuary and it was suggested that it might be possible to reclaim some part of this area by means of artificial plantings of rice grass. The only vegetation at present growing on the mud consists of a dense covering of the common reed (*Phragmites communis*) occupying a zone immediately below the river bank, and stretching outwards for some distance. This is succeeded by a zone of maritime sedges (*Scirpus spp.*) locally known as "salt grass," and beyond this the mud is almost entirely bare and in places very soft. The "salt grass" belt and the mud are submerged at high tide. There is evidence that silting is proceeding at a fairly rapid rate.

Experimental plantings of rice grass were made in May at Seaside, Inchture, seedlings obtained from Essex being used. The plantations were located at various points in order to subject the plants to as great a variety of conditions as possible. The plantations have been visited at intervals during the year, and the results up to the present may be summarised as follows :—

(*a*) There was a considerable loss of seedlings in the early stages, particularly where tidal scour was strong, but a fair proportion survived and grew.

(*b*) The most successful plantation so far is one on deep soft mud near the "salt grass" belt, i.e., fairly near to the upper limit of ordinary tides. The plants there are large and have tillered freely, and in the autumn exhibited some flowering shoots, although no ripe seed had been developed.

(*c*) Successful establishment and good growth were obtained also on firmer mud in deeper water further from the bank.

(*d*) On a firm sandy bank well out from the shore and covered to a considerable depth at high tide, establishment and growth were poor. The anchor roots were poorly developed and the plants had not tillered.

Control of the annual nettle.—An experiment was carried out at Ferrygate, Dirleton, East Lothian, with a view to testing the effects of certain chemical sprays as a means of controlling the annual nettle (*Urtica urens*). This weed is troublesome on land which is devoted largely to the growing of early potatoes, and which receives heavy dressings of nitrogenous manures. The trouble is experienced mainly in the catch crop which is sown after the potatoes are lifted. The weed was stated to have resisted the action of all sprays hitherto tried.

The experiment was conducted in August, the crop being Italian rye grass which was heavily infested with the nettle. The sprays used were :—

(*a*) Iron sulphate at rates of 100 and 200 lb. per acre in 60–70 gallons water.

(*b*) Copper sulphate at rates of 30, 40 and 50 lb. per acre in 50 gallons water.

(*c*) Sodium chlorate at rates of 2½ and 5 lb. per acre in 50 gallons water.

Iron sulphate was found quite ineffective and copper sulphate only moderately effective, having to be used at 50 lb. per acre to produce much effect. Considerable success was obtained with sodium chlorate, a considerable reduction of the nettles being secured where 2½ lb. per acre were used and an almost complete clearance where 5 lb. were used. The Italian rye grass suffered considerable scorching of the leaves, but no permanent harm was done to the crop.

The results of these preliminary trials have been published in the press. The experiment is of interest on account of the low cost of materials, viz., 1s. 3d. per acre at the present price of sodium chlorate.

Pasture experiments.—These were continued during the year at two centres.

Titles of papers issued during the year.

1. Fenton, E. W., and Atkins, W. R. G.: The distribution of pasture plants in relation to soil acidity and other factors. *Sci. Proc. Roy. Dublin Soc.*, **19**, 46.
2. Fenton, E. W.: Boghall Experimental Farm—Grassland studies No. 1. *Edin. and East of Scot. Coll. of Agric., Pamphlet* No. 3 (new series).
3. ———: The influence of sectional grazing and manuring on the flora of grassland. *J. Ecol*, **19**, 1.
4. ———: A botanical survey of grasslands in the south and east of England. *Ibid.*, **19**, 2.
5. Fenton, E. W., and Robertson, E. D. S.: Poisonous and milk tainting plants. *Edin. and East of Scot. Coll. of Agric., Pamphlet* No. 4 (new series).
6. ———: First aid to live stock. *Ibid.*, No. 4 (new series).
7. Cadman, E. J.: Life history and cytology of *Didymium nigripes*. *Proc. Roy. Soc. Edinb.*, **57**, 1, No. 3.

91. GLASGOW : WEST OF SCOTLAND AGRICULTURAL COLLEGE.

Yellow leaf of oats.—A very large number of samples of seed oats was examined in the laboratory with the object of determining the percentage of infection of each with this disease. These samples—from oats grown over the whole of Scotland—were all taken from the 1930 crop.

The method adopted was to take a definite number of grains from each sample and to germinate them in an incubator. After germination each grain was examined microscopically and the presence or absence of the fungus (*H. avenae*) determined. In order that the results might be accurate at least 4 tests were made of each sample. At the same time records were kept of the percentage infection of each sample with other fungi such as *Fusarium*, *Alternaria*, *Puccinia*, *Ustilago*. The samples examined were all taken from one variety (McGill and Smith's Pure Line Potato). This variety is a comparatively new introduction and on that account the seed is still true to type. The results amply proved that yellow leaf is by far the most important oat disease in Scotland, and further that it occurs not only in the south-west but generally throughout the whole country in varying degrees of severity.

The percentage of infection of the samples with *H. avenae* ranged from 4 to 60, and there is a strong indication that there is an intimate correlation between the rainfall in the pre-harvest months and the percentage of infection on the grain. In the summer of 1931 a number of samples of oats grown in the south of England was received, and from the few samples examined it was found that the disease is prevalent there. From the County of Kent one sample was obtained in which over 80 per cent. of the seed was infected. It must be remembered that this summer, and especially the month of July, was very wet, and consequently too much emphasis must not be put upon these results.

Investigations into this disease are being pursued along other lines. For instance, it has been found that there are remarkable differences in the characters of the strains of the causal fungus isolated from oats grown in different parts of Scotland and England. The interpretation of these differences will entail a considerable amount of detailed research work.

The first report on the benefits accruing from seed disinfection of oats has been published (1), and over 50,000 acres of oats were sown in 1931 with disinfected seed. The results obtained were very striking, and it is predicted that over one half of the seed oats used in 1932 will be disinfected.

The increase in yield recorded from the treated over untreated sections of fields in 1931 was very variable. The highest increase in yield of grain was 12½ cwt. of grain. Even at present prices this represents an increased profit of between £4 to £5 per acre. A low estimate of the average increased profit for the 50,000 acres sown with disinfected seed is £1 per acre, or a total of £50,000.

Eelworm disease of potatoes.—A bulletin on this disease was issued in 1930 dealing with investigations into this trouble (2).

This disease so far has not proved amenable to treatment, but a very large number of experiments will be conducted in 1932 on methods of control.

"Rots" affecting swedes.—Preliminary work was done last spring with a view to distinguishing between the various "rots" that affect swedes. In certain parts of the south-west the most important trouble of this nature is known as "Raan." This disease seems so far to have been overlooked by previous investigators. It appears to be of a bacterial nature. Much work, however, remains to be done on this and the other diseases which cause the roots to decay in the pits.

Titles of papers issued during the year.

1. O'Brien, D. G., and Prentice, E. G.: Leaf strips on yellow leaf of oats. *Scott. J. Agric.*, **13**, 3, 272, 1930.
2. Eelworm Disease of Potatoes. Bulletin. *W. Scotland Agricultural College.*

O.

VETERINARY SCIENCE.

92. BANGOR: UNIVERSITY COLLEGE OF NORTH WALES.

Liver rot.—An investigation of the factors which influence the viability of the encysted stage of *Fasciola hepatica*, while emphasising the high resistance possessed by that stage, could not be brought to conclusive ends.

"Strike" in lambs.—An intensive study of this disease was made during the spring. It was concluded that the condition was not caused by the wool-balls so commonly present in the fourth stomach of young lambs, but that it was identical with the "pulpy kidney disease" of New Zealand. It differs from this disease as seen in the Eastern Counties in the age of the lambs attacked. The intestinal contents of lambs dead of this disease, diluted and filtered free from organisms, are frequently highly toxic on intravenous injection into rabbits and mice. This toxicity was not neutralised by the antitoxins of the commoner anaerobes (2).

"Clwy ddu."—This disease of ewes in spring is characterised by more or less sudden death. Sheep on the point of death were obtained from two outbreaks, and media from these cases remained sterile when inoculated from various organs and fluids. The diluted, filtered intestinal contents from the majority of these cases and from sheep found dead of the disease proved highly toxic on intravenous injection into rabbits, mice and sheep.

Braxy.—Trials of toxin antitoxin mixture vaccine gave satisfactory results and further trials, regarded very largely as demonstrations, of *Vibrion septique* anaculture have been laid down in two districts.

Contagious abortion.

(*a*) *The segregation method of control and eradication.*—During the year 47 infected herds have been under observation and 1,808 samples of blood have been taken and examined by the agglutination test. Sufficient work has been done to draw the conclusion that it is often impossible to apply successfully the segregation method of control and eradication under North Wales conditions. In a few instances excellent results have been obtained, but more generally the attempt to eradicate the disease has broken down despite quite frequent testing of the whole herd. The efficient isolation of affected cows is a major difficulty on almost every farm, but the failure of the agglutination test to pick out recently infected in-calf cows before they calve or abort has been responsible for many breakdowns Certainly the method appears only likely to meet with success in this area in herds in which infection is not actively spreading (1).

(*b*) *A comparison of serum and whey agglutination tests.*—It appeared possible that the milk might contain sufficient agglutinins to give a positive reaction in recently infected in-calf cows before the test with serum became positive. It was, therefore, decided to compare the reaction given by whey and by serum in a long series of general herd tests; so the investigation became a comparison of these two tests. At the close of the year the two tests had been applied to samples from 385 cows. It would seem that certain very interesting and useful conclusions may be the outcome of this work.

Fowl typhoid.—Trials of vaccine prepared at the Laboratory of the Ministry of Agriculture have given very good results.

Titles of papers issued during the year.

1. MONTGOMERIE, R. F., and ROWLANDS, W. T.: Failure of the agglutination test to detect *Brucella abortus* infection in in-calf cows. *Veter. J.*, **86**, 463.
2. ——— ———: "Pulpy kidney disease" of young lambs in North Wales. *Ibid.*, **87**, 401.

93. BRISTOL UNIVERSITY.

Preliminary investigations have been made regarding what is locally called "three week scour" of sucking pigs, and it is hoped that further observations will be made on this condition during the next farrowing season.

A survey of the prevalence of worm infestation in sheep, as revealed by the ova present in the faeces, is being carried out in one county.

Enquiries are being made regarding calf scour, which is a very serious menace to calf rearing in some counties.

94. CARDIFF: UNIVERSITY COLLEGE OF SOUTH WALES.

Sheep diseases.

Disease of pregnant ewes.—Investigations were carried out on the cause and treatment of the condition, the chief symptoms of which are progressive torpor, followed by coma and death. Administration of calcium is being tested by various methods.

"*Sway-back.*"—Investigations were carried out on cause and treatment. Heredity seemed to be implicated in one flock.

Summer pneumonia.—Investigations are being continued into the possible association of larvae of *Oestrus ovis* with the condition, and also various complications (1).

Poultry diseases.

Leukaemia.—Investigations are being continued on the cause and infectivity of the condition.

Visceral gout.—Investigations are being made on the cause and also on possible confusion with the disease described by French workers as " Mucrose."

Miscellaneous.—Other investigations were concerned with tumours, *Davainea proglottina*, coccidiosis, and the testing of vaccine for fowl pox.

Cattle diseases.

The diseases investigated comprised redwater, sterility, malignant catarrh, and Johne's disease.

Titles of papers issued during the year.

1. Bisset, N.: The possible association of the sheep-nostril fly (*Oestrus ovis*) with pneumonia in sheep. *Welsh J. Agric.*, **7.**
2. ————: A preliminary note on the treatment of chronic anaemic debility in sheep by inoculation. *Ibid.*, **7.**

95. HARPER ADAMS AGRICULTURAL COLLEGE.

Poultry diseases.—A large amount of data has been collected and some observations made upon fowl paralysis (2, 3). The association of various parasites, particularly cestodes and coccidia, with paralytic symptoms exhibited by birds has received special consideration. Co-operation has been established with Mr. E. L. Taylor, Veterinary Helminthologist, Ministry of Agriculture, in this connection.

The effect of feeding liver, milk and other substances to leucaemic birds is under investigation. Observations upon the breed incidence of certain diseases have been made and are being continued.

Johne's disease.—An inquiry into the value of " Johnin " as a diagnostic agent for Johne's disease in cattle has been carried out when time permitted.

Titles of papers issued during the year.

1. Downham, K. D.: The examination of milk for the presence of tubercle bacilli. A comparison between the cell group method and a method for the concentration of tubercle bacilli in milk. *Veter. Rec.*, **11**, 29, 756.
2. ————: Fowl paralysis. *H. Adams Utility Poult. J.*, **16**, 11, 576-8.
3. ————: Fowl paralysis. Demonstrations of the lesions in a case of fowl paralysis affecting the sciatic nerve. *Veter. Rec.*, **2**, 602.

96. LEEDS UNIVERSITY.

Mineral deficiency in sheep.—In continuation of the experiment carried out in the previous winter, of feeding minerals in the form of pellets to in-lamb ewes, an experiment was carried out on one moorland farm to test whether the ewes would take extra minerals in the form of mineral licks. Mineral bricks were fixed on posts in suitable places on the moor and it was found that after being collected round the bricks a few times the ewes became accustomed to them and licked them regularly.

" Tremblings " or " moss illness " in ewes.—Further experiments were conducted on the treatment of this condition. Included in the above terms are probably two distinct diseases, viz., pregnancy toxæmia, occurring chiefly in ewes before lambing, and lambing sickness, which appears to be similar to " milk fever," and occurs chiefly after lambing.

No satisfactory treatment has so far been found for pregnancy toxæmia, but lambing sickness usually responds to inflation of the udder with air or to injections of calcium gluconate solution.

97. LIVERPOOL UNIVERSITY.

Research work on Johne's disease was confined mainly to investigating the value of " Johnin " as a diagnostic agent in the eradication of the disease from a number of herds. The work entailed tests and retests controlled by autopsies on reacting individuals.

Experimental anti-tuberculosis vaccination of calves with BCG was continued. Post-mortem findings on a number of vaccinated animals confirmed the claims made by the originators of the method. A series of investigations were completed on a comparison of the cell group and concentration methods for the detection of tubercle bacilli in direct milk samples from cases of tuberculous mastitis (1).

Whilst working with tuberculin and Johnin it was observed that group reactions to bacilli of the acid-fast group might occur, and the possibility of a relationship existing between pathogenic and non-pathogenic members of this group in respect to allergic reactions was investigated. Tuberculin, Johnin and an agent termed Phlein prepared from the non-pathogenic *Mycobacterium phlei* were used in a number of herds, and the results would appear to bear out the original observation.

Miscellaneous investigations were carried out on a variety of conditions, the chief being fowl paralysis (4) and ascaris infestation in swine.

Titles of papers issued during the year.

1. Downham, K. D.: The examination of milk for the presence of tubercle bacilli. A comparison between the cell-group method and a method for the concentration of tubercle bacilli in milk. *Vet. Rec.*, **11**, 29, 756.
2. ———: The double intradermal test and the doubtful reactor. *Ibid.*, **10**, 52, 1,200.
3. ———: Three types of acari isolated from pigs affected with sarcoptic mange. *Vet. J.*, **87**, 200.
4. ———: Demonstration of the lesions in a case of fowl paralysis affecting the sciatic nerve. *Vet. Rec.*, **11**, 602.

98. MIDLAND AGRICULTURAL COLLEGE.

Cattle.—Two outbreaks of disease in cattle proved, on investigation, to be due to Johne's disease.

Pigs.—Three investigations were made and in all three the trouble was thought to be of dietetic origin. The exact nature of the dietetic error was not, however, determined.

Poultry.—Inquiry was made into several outbreaks of paralysis, but a factor common to all outbreaks has not been observed.

Investigations limited to post-mortem examinations at the laboratory have shown the conditions coccidiosis and bacillary white diarrhœa to be fairly widespread.

Diagnosis of carriers of the infection of bacillary white diarrhœa has been limited to the testing of a few hundred samples of blood. The period covered does not, however, include the blood testing season.

99. NEWCASTLE: ARMSTRONG COLLEGE, DURHAM UNIVERSITY.

Contagious abortion in cattle.—This disease is prevalent among cows in the North of England. The casual organism *Br. abortus* has been studied in relation to the disease, and measures for control are under investigation (2).

Swingback (ataxia) in lambs.—Preliminary investigations into the nature of this disease have been continued. Microscopical examination of sections of processed spinal cord from affected cases shows that in all probability the essential lesion is an ascending degeneration of certain nerve fibres, which is most marked in areas which correspond to the direct cerebellar and ventro-cerebellar tracts of white matter in the spinal cord. This work is being continued.

Titles of papers issued during the year.

1. Stewart, W. L.: Carbon tetrachloride poisoning in cattle. *Vet. Rec.*, **11**, 11, 283, 1931.
2. ———: The control of contagious abortion. *Northumberland Milk Rec. Soc. Official Hdbk.*, 1931.

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100. WYE : SOUTH EASTERN AGRICULTURAL COLLEGE, LONDON UNIVERSITY.

" *Struck.*"—This is an acute and fatal disease of sheep grazing on the Romney Marsh. The disease is characterised by enteritis, peritonitis and toxæmia which are attributable to a toxin produced by *B. paludis*, growing in a pabulum of the contents of the small intestine. The toxin causes initial injury to the mucous membrane of the intestine, and, passing the mucosal barrier, enters the body, giving rise to peritonitis and toxæmia.

B. paludis toxin has been demonstrated in the contents of the small intestine of affected sheep.

The disease was reproduced by feeding sheep with large quantities of *B. paludis* broth culture and by feeding the bacteria collected by centrifuging when these were resuspended in fresh nutrient broth. Feeding toxin alone did not produce the disease (1, 2).

Gas gangrene infections of sheep.—A large number of post-mortem and bacteriological examinations have been made, and the survey of the bacteriology of the disease has been an extensive one. As a result *B. chauvoei* has been definitely incriminated as the common causal organism of gas gangrene in sheep. Frequently *V. septique* was recovered, but only in circumstances where the possibility and probability of its being a post-mortem invader were apparent.

Sheep exposed to risks of contracting the disease should be immunised against *B. chauvoei.* Owing to the irregular occurrence of gas gangrene among sheep on the Romney Marsh, it is doubtful whether the immunisation of the whole flock would be undertaken by farmers. Owners, however, would willingly give a prophylactic inoculation to individual animals when it was known that these ran a grave risk of contracting the disease. Ewes which have received manipulative assistance at lambing run such a risk. *B. chauvoei* immune serum was prepared and it appeared to give most satisfactory results when the shepherd inoculated the ewe immediately after lambing. Laboratory experiments confirm the value of the serum used in this manner (3).

" *Black disease.*"—A large number of bacteriological examinations have been made on sheep from the Romney Marsh which have died in circumstances where there was the suspicion that death might be due to an anaerobic bacterial infection. In one instance only a bacillus apparently identical with the *B. oedematiens*-like bacillus which is considered to be the causal organism of "black disease" in Australia and New Zealand was isolated. The same organism was recovered on three occasions from a total of five examinations on material received from sheep from a different part of the country. Therefore, though this micro-organism appears to be of little importance on the Romney Marsh, it may be a cause of sheep mortality in some areas in Britain (4).

Bacillus chauvoei.—A comparative examination of ovine and bovine strains of *B. chauvoei* has shown these to be identical except in their serological characters.

Both ovine and bovine strains possess H and O antigens; the O antigen is common to both but the H antigen is specific for its own particular strain, ovine or bovine (5).

Titles of papers issued during the year.

1. McEwen, A. D., and Roberts, R. S.: "Struck" enteritis and peritonitis of sheep caused by a bacterial toxin derived from the alimentary canal. *J. Comp. Path. and Therap.*, **44**, 26, 1931.
2. McEwen, A. D.: Summary of preliminary investigations on "Struck," an acute disease of sheep. *J.S.E. Agric. Coll.*, **28**, 216, 1931.
3. Roberts, R. S., and McEwen, A. D.: Gas gangrene infections of sheep. *J. Comp. Path. and Therap.*, **44**, 180, 1931.
4. McEwen, A. D.: A sporulating anaerobic *bacillus*, similar to the causal organism of "black disease." *Ibid.*, **44**, 149, 1931.
5. Roberts, R. S.: Ovine and bovine strains of *B. chauvoei*. *Ibid.*, **44**, 246, 1931.

P.

AGRICULTURAL
and
DAIRY BACTERIOLOGY.

101. ABERYSTWYTH : UNIVERSITY COLLEGE OF WALES.

Bacteriological efficiency of milking machines.—An article on this problem has been published (1). A comparison of machine and hand milking is being continued.

Udder flora.—An investigation into the qualitative nature of the flora of aseptically produced milk is being carried out. In addition to plating dilutions on standard agar, blood agar plating and the Burri smear culture method are being employed.

Examination of the yeast content of fresh and ripened cream during hot weather.—The prevalence of lactose fermenting yeasts in samples of farm cream during the summer months is being investigated.

Bacteriological examination of ice-cream.—Sixty-four samples of ice-cream have been examined bacteriologically. Although the majority of the samples gave bacterial counts over a million per cubic centimetre, with coliform organisms often present in 1/1,000 cc., it has been found that certain local vendors are able to produce an article with a bacterial content consistently under 100,000 and with coliform organisms not present in 1/10 cc. This has been attained by efficient pasteurisation of the mix.

It is intended to produce during the next season an ice cream from raw products with a bacterial content within this standard.

The majority of the vendors make up a product giving 3–4 per cent. butter fat, though a few sell an ice cream with over 8 per cent fat.

Titles of papers issued during the year.

1. Thomas, S. B., and Phillips, R. : The efficiency of the milking machine. *Welsh J. Agric.*, **7**, 227, 1931.
2. Thomas, S. B. : Seasonal variations in the bacterial content and keeping quality of milk. *Ibid.*, **7**, 310, 1931.
3. Thomas, S. B., and Morgan, G. T. : Some factors influencing the keeping quality of butter. *Ibid.*, **7**, 290, 1931.
4. ——— ———: Guide to the conduct of butter competitions. *Ibid.*, **7**, 298, 1931.
5. Thomas, S. B., and Jones, Hetty : The influence of the fat content on the keeping quality of milk. *Ibid.*, **7**, 304, 1931.

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102. BANGOR : UNIVERSITY COLLEGE OF NORTH WALES.

Rapid souring of milk.—Examination of rapidly souring milk showed the presence of large numbers of spore-forming organisms. Investigation revealed the fact that the churns were being exposed to the air in the yard where hay was carted. Due precautions were taken to eliminate contamination from this source and no further trouble was experienced.

Other investigations have been made into cases where high bacterial counts and the presence of *Bacillus coli* have caused taints and rapid souring in the milk supply. In such cases the trouble has usually been traced to a general lack of cleanliness during production and subsequent handling.

Spongy curd.—A case of soft, spongy curd at a cheese-making farm was investigated and found to be due to insanitary methods of milk production and cheese manufacture. On steps being taken to improve the conditions generally, there was a gradual improvement in the quality of the cheese produced.

Use of " starter."—Efforts to improve the keeping quality of farm butter by the use of " starter " for cream ripening have been continued, and four farms have carried out experiments on this work. The investigation has now extended over a period of 18 months, and so far results show that there has been a decided increase in the keeping quality due to the use of " starter." The average increase ranges from ½ day to 3¼ days at the different farms.

Water supplies.—Investigations have been made into the conditions of the water supplies on both milk-producing and butter-making farms. Thirty-six supplies were examined, and of this number over 40 per cent. were condemned owing to contamination with coliform organisms.

103. BRISTOL UNIVERSITY.

Thermophilic organisms in milk.—It is regretted that the investigation connected with thermophilic organisms in milk commenced during the early part of the period under review has had to be suspended owing to pressure of other work.

Postal transmission of milk samples.—An investigation is in progress into the possibilities of cork-lined sample boxes for the transmission of milk samples through the post. The results so far obtained would seem to indicate that any slight benefit to be derived from the use of insulated boxes of this type would not warrant the extra expense involved.

Registers of accredited producers.—A considerable amount of work has been done, and is still in progress, on the methods employed in the examination of samples submitted in connection with registers of accredited producers. The possibilities of the reductase test in combination with the test for the presence of coliform organisms is being explored, and a scheme has been drawn up which it is hoped to put into operation on an experimental basis in Wiltshire in the coming year.

Mastitis.—In consultation with the National Institute for Research in Dairying and in co-operation with the Adviser in Veterinary

Science, an autogenous vaccine was prepared for injection by the local veterinary surgeon into a large dairy herd in Wiltshire, where an extensive outbreak of mastitis of chronic form was causing very considerable financial loss. At the request of the Agricultural Organiser the vaccine was prepared in order to demonstrate to farmers in the county the possibilities of such treatment.

Title of paper issued during the year.

1. Miles, C. S.: Tuberculosis in relation to our milk supply. *Gloucester Dairy Students Assoc. Mag.*, Apr., 1931.

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104. LEEDS UNIVERSITY.

Poor keeping quality of milk.—These investigations showed that, in almost every case, methods of production were not good. Insufficient preparation of the cows and unsterile utensils were the chief faults.

Sliminess of milk.—Several cases of sliminess of the cream of milk were investigated. In most cases this was caused by organisms of the *B. lactis aerogenes* type gaining entrance to the milk during milking. The sliminess was generally overcome by thorough preparation of the cows. In other cases the sliminess was due to organisms from a contaminated water supply gaining entrance to the milk.

Taints and abnormal flavours.—Four cases of abnormal flavour of milk were also found to be due to faulty preparation of the cows. These milks were heavily contaminated with coliform organisms which had entered the milk during milking and which were responsible for its abnormal flavour.

The detection of latent mastitis in cows.—During the year samples of milk were taken from a number of cows suspected of suffering from a latent mastitis. A preliminary examination was made by using Brom Cresol papers but in some cases this was not found to give as satisfactory results as the centrifugal method.

A persistent contamination of samples of "certified" milk with Bacillus lactis aerogenes.—An interesting case was the subject of investigation (1). "Certified" milk had been produced on this farm for over five years with success. In the autumn of last year, however, samples of the milk failed to satisfy the bacterial standard with regard to the presence of coliform organisms. The coli organism was not of the usual type, namely, *B. coli communis*; it was of the *B. lactis aerogenes* variety.

After much work, which involved the examination of a very large number of samples of milk, water, manure, etc., it was concluded that the organism was gaining entrance to the milk from two sources, namely, from the outside of the udders, and from a heavy contamination of the fore milk with the organism. The organism was very slimy and adhered to the outside of the udder even after a very thorough washing. The trouble was overcome to some extent by the use of soap and a weak disinfectant in the washing water. It is probable that the original source of the organism was the manure of the cows, as the organism was found in large numbers in the faeces.

Another similar case was investigated on another " certified " farm later in the year.

Title of paper issued during the year.

1. Chalmers, C. H.: An investigation into the presence of *Bacillus lactis aerogenes* in samples of " Certified " milk. *Proceedings of the Society of Agric. Bacteriologists*, 1931.

105. MIDLAND AGRICULTURAL COLLEGE.

Taints in sterilized milk.—The development of smoky, carbolic or coconut off-flavour in sterilized milk at one dairy plant was investigated. Numerous samples of the tainted product were examined, and in every instance microscopic examination showed the presence of large numbers of spore-forming bacilli.

Milk samples from individual farms were examined, and also samples at different stages of processing at the plant. A few of the farm samples developed the characteristic taint after sterilizing, but in view of work carried out at Reading it is doubtful whether the infection of raw milk supplies at farms was sufficiently intense to cause mass infection of the bulked product. When the use of milk from suspicious farms was discontinued, and the bottles and other equipment used at the plant were sterilized before use, the taint disappeared.

Detailed cultural examination of organisms isolated was not undertaken, but in several cases pure cultures isolated reproduced the taint under laboratory conditions.

Strong flavour in milk.—The development of a strong flavour in milk produced on several farms in Leicestershire has been studied. The milk develops a taste and smell resembling that of a dirty dish cloth within 12 to 24 hours after milking, and fails to sour in a normal manner. The defect is not confined to farms where lack of care in production exists, but has been encountered where great care is taken to prevent contamination. It has been established that the taint is bacteriological in its nature, but attempts to reproduce the taint either by the use of pure or mixed cultures of organisms isolated have not been successful.

In one instance the water supply was open to suspicion, a small quantity inoculated into sterile milk reproducing the taint. It has been ascertained that the taint is common in Leicestershire, and it is possible that further opportunities of studying the problem will be presented.

Fishy flavour in milk.—Assistance was given in the testing of milk samples during the course of an experiment at the College Farm to ascertain the effect of feeding molassed beet pulp on the flavour of milk.

In co-operation with the Advisory Chemist one case of fishiness in milk was found to be due to the feeding of molassed beet pulp. When its use was discontinued, the taint disappeared.

106. NEWCASTLE: ARMSTRONG COLLEGE, DURHAM UNIVERSITY.

Brucella abortus.—Work along the lines already reported has been continued and a report was submitted to the summer meeting of Bacteriologists at Cirencester in July, 1931.

The experimental work undertaken in co-operation with the Veterinary Adviser concerning the elimination of contagious abortion, has been continued with marked success.

Eradication of bovine tuberculosis.—The milk work undertaken with the Borough of Berwick-on-Tweed has suffered another prolonged delay.

107. WYE: SOUTH-EASTERN AGRICULTURAL COLLEGE, LONDON UNIVERSITY.

258 samples of afternoon milk were tested for total count, both at 24 and also 28 hours old, and also tested for keeping quality. The results give no indication that the nine hours difference in average keeping quality is connected with the difference in age on testing (1).

A comparison of 2,808 samples of morning milk and 3,032 samples of afternoon milk collected over a period of seven years shows that the afternoon samples average nine hours' less keeping quality than morning samples of similar total count (2, 3).

Titles of papers issued during the year.

1. Barkworth, H.: Keeping quality of milk and the age on testing for total bacterial count. *J. Hyg.*, **31**, 3, 1931, two tables.
2. ———: Normal variations of keeping quality. *J.S.E. Agric. Coll.*, **28**, 273, 1931, two tables.
3. ———: The keeping quality of afternoon milk. *Ibid.*, **28**, 270, 1931, three tables.
4. True time required for sterilisation. *Zbl. Bakt.*, **2**, 84, Nr. 15/18, 353. 1931.

108. EDINBURGH AND EAST OF SCOTLAND COLLEGE OF AGRICULTURE.

Decomposition of urea in soils.—Work was continued on micro-organisms concerned in the decomposition of urea in soils. A description of experiments on the rate of the ammonification of urea in mountain and heath, arable, permanent pasture and forest soils in Scotland and also in certain alkali soils obtained from Egypt has been published (8). Further work on a considerable number of pure cultures isolated from soils is now in progress.

Nitrogen-fixing bacteria in soils.—Dr. M. Selim, who recently spent two years working as a research student in this laboratory, has published the main results of his investigation of the nitrogen-fixing bacteria in soils (9).

The Burri smear-culture method for the determination of the bacterial content of milk.—At the International Dairy Congress in July, 1928, Professor Burri described a new method for the determination of the bacterial content of milk. The technique recommended involves the use of calibrated platinum loops for the measurement of small quantities of milk which are then spread over the surface of one or more dried agar slopes. The cultures so prepared are incubated, the numbers of colonies which develop on them are determined, and the bacterial content of the milk sample in question is then calculated. Among the advantages claimed for the method are the simplicity of the technique, economy of time and material, and the facts that the cultures can be used for qualitative as well as for quantitative studies and that determinations can be made in any part of a dairy or milk plant. The advantages claimed appeared to indicate that the Burri method might prove to be of considerable value in advisory work where large numbers of milk samples frequently require to be examined in a comparatively short time. An investigation of the accuracy of the method, when compared with that of the ordinary pipette-plate technique, was therefore undertaken. The work, which is still in progress, appears to indicate that the Burri technique is decidedly less accurate than the plate method and that it is subject to an error which is so large that the method is of little value for making accurate determinations of the bacterial content of milk samples (4).

Although the Burri method is not sufficiently accurate for general use in the routine examination of milk samples, it may still prove to be of considerable value for the detection of sources of gross contamination in the production and distribution of milk. In this connection the simplicity of the technique and the fact that it can be applied outside the laboratory are important points in its favour.

Intermittent high bacterial counts in certified milk.—High bacterial counts of an intermittent nature are frequently encountered in examinations of certified milk. They may persist for a few days only and generally vanish as suddenly as they appear. As a rule, therefore, it is extremely difficult to obtain any information as to their cause.

An outbreak of high counts of this type recently occurred in samples from a certified herd. As soon as the occurrence of high counts was detected, individual samples were taken from all cows in the herd which were known to have previously suffered from mastitis. The samples were obtained from quarters which had recovered as well as from unaffected quarters in udders bearing one or more blind teats. High counts were obtained from samples in both categories. The micro-organisms concerned were streptococci and micrococci.

Coliform organisms in graded milk.—The investigation of the types of coliform organisms in certified milk referred to in previous reports has been continued.

Plant diseases.—Cases of plant disease were examined and reported upon.

Cultivation of lucerne.—Enquiries regarding sowing, cultivation and inoculation of lucerne were dealt with and seed was inoculated for a number of farmers (5).

Life cycle of the butyric acid bacillus (*B. saccharobutyricus von Klecki*).—During the year the two final papers in the series dealing with this subject were prepared for publication (1, IV–V). Papers dealing with certain aspects of the subject were also read before the local section of the Institute of Brewing and the Society for Experimental Biology (2, 7).

Titles of papers issued during the year.

1. CUNNINGHAM, A.: The life cycle of *B. saccharobutyricus* von Klecki :—
   - I. Methods and cultures used. *Zbl. Bakt.*, **II Abt,** 25, 1930.
   - II. The large rod, coccoid and short rod phases. *Ibid.*, **II Abt,** 481, 1931.
   - III. The slender rod phase and secondary transformations. *Ibid.*, **II Abt,** 1, 1931.
   - IV. Special morphology and methods of reproduction. *Ibid.*, **II Abt,** 22, 1931.
   - V. Confirmatory evidence. *Ibid.*, **II Abt,** 219, 1931.
2. ———— : Recent work on the life cycles of bacteria. *J. Inst. Brew.* **28** (new series), 110, 1931.
3. ———— : The formation of an aroma resembling that of amyl alcohol in milk. Read at meeting of Sect. 2 of the 9th Internat. Dairy Cong., Copenhagen, July, 1931.
4. ———— : Some observations on the Burri smear-culture method for the bacteriological examination of milk. Read at meeting of Soc. of Agric. Bacts., Reading, Sept., 1931.
5. ———— : The cultivation and inoculation of lucerne. *J. Farmers' Club*, 33, 1931.
6. ———— : Studies on soil micro-organisms. Thesis for Degree of D.Sc., Univ. Edinb., July, 1931.

7. Cunningham, A., and Gibson, T.: The filterable gonidial stages of bacteria. Read at meeting of Soc. for Exp. Biol., Edinb., Mar., 1931.
8. Gibson, T.: The decomposition of urea in soils. *J. Agric. Sci.*, **20**, 549, 1930.
9. Selim, M.: The nitrogen-fixing bacteria in soils. *Zbl. Bakt.*, **II Abt, 311**, 1931.

109. GLASGOW : WEST OF SCOTLAND AGRICULTURAL COLLEGE.

Milk Production.

Feeding and breeding problems.—The study of breeding, feeding and management problems is undertaken by the Department, the greater portion of the time being taken up with feeding experiments and the study of the milk records collected by the Scottish Milk Records Association (1, 2, 3, 4, 5, 6, 7).

During the year it has been found that, weight for weight, dried potatoes are of about the same value for milk production as barley meal, and, provided they can be dried and placed on the market at a reasonable figure, compared with other feeds, this would form a suitable outlet for surplus potatoes in years of abundance.

In continuation of the work on feeds of medium protein content, there has as yet been found no great difference in the value of feeds of similar protein content, when used in a good mixed ration. In spite of this, there is a tendency for farmers to demand certain feeds, and when these are scarce they will pay high prices for them. Equally good results could be obtained by the purchase of other feeds, of similar protein content, and much lower price.

As a result of a study of the Scottish Milk Records a list of the proven sires in the dairy breeds throughout Scotland is in process of preparation. A section of this will shortly be ready for publication.

Milk Utilisation.

Starters.—Research work on starters has been continued, and the utility of selected lactic acid bacteria in cheesemaking and in buttermaking has been determined by a long series of trials. The value of strain has again been demonstrated and the effect of combining two or more pure culture types in one starter has been clearly established. For cheesemaking purposes, the association of selected strains of *B. acidophilus* with *Streptococcus cremoris* and with *Streptococcus lactis* has given excellent results, when a good quality of raw milk has been employed.

Because of the experience of many practical cheesemakers who find some difficulty in the management of pure cultures, attention is being concentrated on the factors which determine the viability and vitality of the lactic acid bacteria in milk culture. The most important factor is shown to be the reaction of the primary milk; a single passage of active starter through unsuitable milk may cause it to lose much of its vigour and to slow it down to such an extent that it is no longer desirable for cheese or buttermaking.

Pure culture starters which have been consistently grown in sterilised milk lose much of their ability to ferment raw milk rapidly; consequently such cultures, while suitable for pasteurised milk or cream, are less valuable in cheesemaking. Investigations have shown that a sensitive culture may be greatly invigorated by the association with certain types of moulds, and a method has been found by which, after being so invigorated, the mould can be removed from the culture without resorting to replating, which always weakens the culture. The effect of the unheated bacteria-free serum of raw milk on pure culture starters is at present under investigation and an attempt is being made to determine what constituent in the raw milk carries the factor which exerts a restraining effect on starter organisms.

Putrefaction in cheese.—In the autumn and winter of 1930–31 a recrudescence of the obnoxious taint was reported in the produce of some cheesemaking dairies, and caused alarm to the trade. Further investigation suggested that infection may arise from contaminated equipment, and there is evidence for the statement that in some cases the recurrence of the taint is due to a " carry over " from the previous year of the infection by the utensils and cheesemaking equipment. Before any scheme of disinfection of premises and equipment could be recommended it was necessary to determine not only the most appropriate disinfectants but also the relative cost of these agents, the strengths of the solutions which would be effective, and the most suitable methods of employing them under farm conditions. In relation to hypochlorite solutions it was found that they had to be rendered slightly acid before they exercised any lethal effect on the spores of the taint-producing organism; in neutral or alkaline solution their disinfecting power towards these putrefactive bacteria appears to be distinctly limited. Detailed instructions on the method of disinfecting the dairy premises and equipment on the cheesemaking farms were published at the beginning of the cheesemaking season in the local papers throughout the various cheesemaking areas. A printed brochure was also prepared and circulated through the intermediary of the County Instructors (9).

Apart from the probability of infection being derived from contaminated equipment, the part played by the raw materials used in cheesemaking in the transmission of the taint is being closely studied. Bacteria of a putrefactive type may occur in samples of commercial rennet extracts, but the relative numbers are nearly always small, and no cases of the taint have been experienced in normal experimental cheeses caused by the use of commercial rennets, even those from which some putrefactive bacteria could be isolated. Nevertheless it is possible that some batches of imported rennet may be more highly contaminated than others. Hence, until it is possible to examine not only different brands, but also individual consignments of rennet extracts used by our cheesemakers, the relationship of the rennet to the incidence of the taint cannot be finally determined. Samples of rennet used by cheese-makers in S.W. Scotland during the 1931 season have been collected and a bacteriological examination of these with special reference to the presence of putrefactive bacteria is being made. The production of bacteria-free rennet has been attempted and it has been found possible by filtration to remove putrefactive and other bacteria from commercial rennet extracts with a loss of only 15–25 per cent. of the strength.

At the same time nothing has emerged from recent investigations to controvert the opinion that a primary source of the taint was infected starter.

Experimental cheeses, in which were putrefactive bacteria isolated from stinking cheeses, from rennet, and from starter preparations, have been made in recent time, and when of an appropriate age will be examined. Preliminary studies would appear to suggest that the putrefactive organism by itself is not well equipped to produce the dreaded taint, and that it requires the help or association of other non-putrefactive bacteria to enable it to produce its well recognised effects.

Some stinking cheese examined have been found to contain more than one type of putrefactive organism.

Freedom from the dreaded taint can be guaranteed only if (*a*) the utensils and equipment are sterilised or effectively disinfected, (*b*) a pure culture starter from a guaranteed source is used, and (*c*) a bacteria-free rennet is employed.

Butter flavour.—Recent work on the Continent has shown that starters which have a favourable influence on the flavour and aroma of butter are characterised by a definite production of acetyl-methyl-carbinol, which by oxidation results in the formation of diacetyl, reputed to be the factor finally responsible for the aroma of butter. An endeavour is being made to select appropriate strains of the *Streptococcus cremoris* type (Storch's No. 18) which will produce the desired results and which will permit of a thorough washing of the butter with a view to maintaining its keeping properties without losing the flavour and aroma developed during the ripening of the cream.

Experiments have already been made to determine whether it is possible to impress the desirable flavour on sweet cream butter and on margarine with the use of diacetyl (added in minimal amounts to the cream before churning or to the fatty emulsion used in margarine making).

It will not be possible to express a final opinion on this procedure until the experimental butters have been under storage for a time, but so far as margarine is concerned the results hitherto obtained are promising.

Titles of papers issued during the year.

1. McCandlish, A. C., and Kay, R. R.: The need for selection of dairy bulls. *Scott. J. Agric.*, **13**, 381, 1930.
2. McCandlish, A. C.: Characteristics of a good ration. II. Variety. *Ayrshire Cattle Soc. J.*, **2**, 132, 1930.
3. ———: Characteristics of a good ration. III. Bulk. *Ibid.*, **3**, 10, 1931.
4. ———: The storage of swedes for spring use on dairy farms. *Bull.* 122. *W. of Scot. Agric. Coll.*, Mar., 1931.
5. ———: Characteristics of a good ration. IV. Succulence. *Ayrshire Cattle Soc. J.*, **3**, 47, 1931.
6. ———: The feeding of roots to dairy cows. *World's Dairy Cong. Conf. papers, first section*, 73, 1931.
7. ———: A day in Denmark. I. The land and crops. *Ayrshire Cattle Soc. J.*, **3**, 96, 1931.
8. Leitch, R. H.: Problems of dairying. *Yorks. Agric. J.*, 1931.
9. ———: Cheese taint. Disinfecting of cheese-making dairies. *Special brochure. W. of Scot. Agric. Coll.*, 1931.
10. ———: *B. bulgaricus* as a starter in Cheddar cheese-making. *Maelkeritidende, Internat. Cong. Number*, 17th July, 1931.
11. ———: Hygienic milk production. *Trans. Roy. Sanit. Assoc. Scot.*, 1930.
12. ———: Effect of foremilk in cheese-making. *Scott. J. Agric.*, **14**, 2, 1931.

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ECONOMICS.

110. ABERYSTWYTH : UNIVERSITY COLLEGE OF WALES.

Relation of output to gross income.—Amongst published results of research the results of a study of the relation of output to gross incomes of farmers are interesting (1). Statistical examination of the financial results of a number of farms showed a close association between gross output and income per acre. There were also close associations between output and capital, and between output and rent. The higher rentals are associated with the higher outputs, and these with the higher profits or earnings. So far as could be ascertained there was no indication that these farmers would be well advised to reduce their output. Rather there appeared on examination of individual accounts to be opportunities for increasing yields and thereby sales.

Efficiency in milk production.—A study of some conditions of efficiency in milk production showed that the chief factors were cost of feed against yield of milk, size of herd against cost of labour, and amount of depreciation on herd against proportion of purchased cows (5). The cost of feed per 100 gallons of milk varied to some extent with the yield per cow, of labour with size of herd, and of depreciation with the proportion of bought cows.

Financial results of Welsh farms.—Financial results of Welsh farms 1930–31, as far as available at the end of September, showed that only two farms had suffered direct loss, but on the whole the results were less satisfactory than in the previous year (12). The average income of farmers, including those meeting losses, was about £147, of which £53 may be reckoned as interest on capital and £94 as earnings of the farmer in some manual work and management. The average income of farm families, including wages due to sons, daughters, etc., was £195. Some of the recent weaknesses in markets and declines in prices had not had their full effects during the year under review, and it is probable that they will be more fully reflected in the accounts for 1931–32.

Titles of papers issued during the year.

1. Ashby, A. W.: Does the higher farming pay ? *Welsh J. Agric.*, **7**, 1931. (Reprinted.)
2. ———: Marketing livestock. *Rept. of Conf. of Agric. Organisers.* Published by Min. Agric., 1930.
3. ———: Agricultural economics as applied economics. *Proc. Internat. Conf. Agric. Economists*, 1930. (Reprinted.)
4. Ashby, A. W. (with Miss M. K. Ashby): Rural education. *The Teacher's Guide*, **3**, 36 pp. Blackie and Co., 1930.
5. Howell, J. P.: Some factors of efficiency in milk production. *Welsh J. Agric.*, **7**, 1930. (Reprinted.)
6. Jones, J. Morgan: *Improvement in the technique of farm processes in Germany.* 30 pp. Mimeographed for private circulation by the Development Commission, Lond., 1930.
7. Davies, J. Llefelys: Seasonal distribution of labour on Welsh farms *Welsh J. Agric.*, **7**, 1931. (Reprinted.)

8. Davies, J. Llefelys : Labour aspects of farm layout in Wales. *Ibid.*, 7, 1931. (Reprinted.)
9. ———— : Cost accounts on a cheese farm. *Ibid.*, 7, 1931. (Reprinted.)
10. Lewis, Thomas : Farmers' control of livestock auctions in Wales. *Ibid.*, 7, 1931. (Reprinted.)
11. General : *Report of conference on development of agricultural co-operative business, Aberystwyth,* May, 1931. (Issued by the Department.)
12. *FARM AND MARKET.*
    2, 2, 1930.
        The harvest in Wales 1930.
        Financial results of some Welsh farms.
        Capital requirements of some Welsh farms.
        Butter prices, 1930.
    2, 3, 1931.
        Report on marketing live stock in Wales.
        Egg production, supplies and prices.
        Prices of eggs and feeding stuffs.
        Cheese production, costs and returns.
    2, 4, 1931.
        Supplies and prices of sheep.
        Sheep skins and pelts.
        Mortality amongst sheep.
        Sheep costs and returns.
    3, 1, 1931.
        The financial situation.
        Financial results of some Welsh farms, 1930-31.
        Crops in Wales, 1931.
        Distribution of farm income and expenses.
13. *AGRICULTURAL BUSINESS.*
    1. Sept., 1930.
        Membership, trade and capitalisation of co-operative societies Wales.
        Purchase of farm materials in Wales.
        Livestock transport and marketing associations.
    2. Dec., 1930.
        Co-operative salesmanship. (Premises, display, advertisement).
        Manufacture of butter and cheese. A liquidated dairy society.
    3. Apr., 1931.
        The agricultural co-operative movement in Wales, 1929. (A general review and financial analysis), 20 pp.
    4. July, 1931.
        Non-profit co-operatives.
        Revolving fund method of financing marketing societies.
        Pooling in co-operative organisations.

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111. BRISTOL UNIVERSITY.

Farm management studies.—Financial accounts are received from over 240 farms and full costing is carried out on nine farms. The work in statistical correlation referred to in last year's report has been continued, and the results have been embodied in a special series of reports. The second of these issues (1) establishes a high degree of correlation between production and costs, but a rather low degree between production and capital. The third issue (2) related the changes in the proportion of arable land on a farm to changes in production, capital, total costs and labour costs. It was found, for example, that in Wiltshire, Gloucestershire, Hereford and Worcestershire, each of these factors showed a decline as the proportion of arable increased. In Somerset, however, capital, total costs and labour costs all increased with increasing arable, while production was, at the same time, falling. The exact reason for the rather striking difference between Somerset and the other counties has not yet been ascertained, but the more intensive studies being carried out along these lines will, it is hoped, throw some light upon the problem. It has been found that the farmers concerned are keenly interested in these attempts to apply rigid mathematical reasoning to farm account data. The reports are made as non-technical as possible and are discussed at meetings held at various centres in the Province.

Sugar beet production.—During the year the results of the investigation into the costs of production of sugar beet in Hereford and Worcestershire were issued as a University Bulletin (3). This work is being continued in a modified form.

Strawberry production.—A special inquiry into the cost of production of strawberries has recently been instituted. The chief difficulties are (a) the small acreage per grower, (b) the large amount of unpaid family work, and (c) the numerous strains and varieties cultivated.

Titles of papers issued during the year.

1. Dawe, C. V.: Production in relation to capital and costs. *Univ. Bristol. Continuous Series on Farm Management*, 2.
2. ———: Influence of arable upon production. *Ibid.*, 3.
3. ———: Cost of production of sugar beet in Hereford and Worcestershire (1925-6—1929-30). *Univ. Bristol Bull.*, 6.

112. CAMBRIDGE UNIVERSITY.

Economic survey of Hertfordshire.—An economic survey of Hertfordshire agriculture was commenced in September, 1930. The local Agricultural Organiser co-operated in the field work for this study, and records were obtained from over 300 farms in the county. As considerable care was exercised in the selection of the samples, the results secured can be assumed to be reasonably representative of local conditions. A report, describing the economic organisation of the agriculture of the county, the incidence of the depression, and the factors influencing profitableness on individual farms, was issued in August (1), and was well received by the press. The county Agricultural Organiser was particularly enthusiastic as to the value of this publication for advisory purposes.

Farm management survey.—Preparatory work was undertaken in view of the organisation of a large-scale economic survey in the

Province, towards the cost of which the Ministry of Agriculture undertook to contribute a supplementary grant. The primary objective of this enquiry is to secure data relating to the economic position of cereal production in the Eastern Counties Province, and, for biological reasons, it is considered advisable to continue the investigation over a period of three consecutive years. Preparatory work involved the definition of the universe, and the selection of the sample. It was decided that the universe should comprise certain definite soil types, viz., the clays, sands and chalks, and medium loams, and that farms below 20 acres in size should be omitted from the survey. The sample has been chosen in such a way that, within each soil type, selection is completely random. It is hoped to secure in the neighbourhood of 1,000 farm records during each year the survey is continued.

Wheat and sugar beet production.—The cost of production studies of wheat and sugar beet have been continued, data relating to some 100 fields of the former crop and 50 fields of the latter crop being secured.

Strawberry production.—An investigation of the cost of producing strawberries has been commenced, in co-operation with the Bristol Advisory Economist, with a view to obtaining a basis for price contract discussions between growers and canning factories. Promises of assistance have been given by some 30 growers distributed mainly in the Wisbech and Cottenham areas.

Cost data.—Work upon the full cost data collected in 1927-29 has been completed, and the results, incorporating some notes on the economic aspects of rationing livestock, were published in Report 17 (2).

Titles of papers issued during the year.

1. *An economic survey of Hertfordshire.* Report No. 18. Farm Econ. Br., Dept. of Agric., Camb. Univ. Price 2s. 6d. net.
2. KIRKPATRICK, W. H.: *An economic and financial analysis of sixteen East Anglian farms*, 1927–29. Report No. 17. Farm Econ. Br., Dept. of Agric., Camb. Univ. Price 1s. net.

113. HARPER ADAMS AGRICULTURAL COLLEGE.

Costings and financial accounts have been finally dropped and their place taken by (a) crop costing surveys, on the lines of the sugar beet survey, of beet, carrots, potatoes, swedes and mangolds; and (b) a large scale poultry survey costing scheme of a new type.

The Department continued to cost in detail the two College farms, to supervise and assist four farms which are costing on systems of their own, and to keep watch on the 35 financial accounts which have been under the constant supervsiion of the Department.

114. LEEDS UNIVERSITY.

Rural industries.—The ramifications of agricultural economics have been well brought out in connection with an enquiry, recently begun, into village industries as a means of increasing rural employment. If more men can be brought back to the land, with the possibility of complementary employment or additional employment for their women folk in local industries and crafts, some contribution will be made to the welfare of the rural population.

The value of the new sugar beet industries is obvious ; the possibility of an increase in canning factories or co-operative creameries and bacon factories is likewise great. But a serious contribution may be made by reviving many of our dying crafts closely allied to agriculture, of which we have several examples in Yorkshire—the making of baskets, hoppers, crates, etc. ; the making of besoms and sheep hurdles ; the revival of the village smith and carpenter specialising on local hand-made products. All these can be stimulated with an ultimate beneficial effect on agriculture.

Agricultural history.—In the sphere of historical research, work has gone steadily forward, and the results of the investigation at Hooton Pagnell are virtually ready for publication. In the work on " Hooton Pagnell : the agricultural evolution of a Yorkshire Village " the village has been regarded as the nation in epitome, and so far as possible the agricultural history of the country has been traced by reference to recorded changes at Hooton, wherever original documentary evidence was available.

Commencing with a description of the village in 1086, the main phases of the history of the village are traced with special reference to ownership, land tenure, the enclosure of the land, the history of tithes, etc., which throw light on the present organisation of agriculture there. In connection with the investigation several maps have been prepared.

Miscellaneous.—Investigations on the following subjects which were commenced in previous years are being continued :—

The economics of production and disposal of peas for picking green ; the flax industry round Selby and its effect upon agriculture ; the economic position of the potato crop in Yorkshire ; and the economics of sheep husbandry.

Titles of papers issued during the year.

1. Ruston, A. G. : Advisory work on farm management. *Proc. Internat. Conf. Agric. Econs.*, 2.
2. ——— : Effect of present-day legislation on the ownership and management of land. *J. Chartered Surveyors' Inst.*, 4, 3 and 4.
3. ——— : Some problems of the milk producer. *Proc. Internat. Dairy Cong.*, 1931.

4. RUSTON, A. G., and NICHOLS, H. E. : Pigs and forage crops. *Pig-breeders Ann.*, 1931-32.
5. ——— ———: Economics of milk production. *Lancs. County Milk Red. Yr. Bk.*, 1931.
6. RUSTON, A. G., and WITHERS, D. C. : Economic value of poultry on the farm. *Yorks. Federation of Poult. Soc. Hdbk.*, 6, 1931.

115. MANCHESTER UNIVERSITY.

Economy in feeding for milk production.—The fall in the price of milk and in the value of sheep and wool has given interest and force to the work of reducing the cost of production. The cost of feeding is treated as a subject of primary importance. As this amounts on an average to more than 60 per cent. if the total cost of producing milk, the use which farmers made of their fields to obtain food, together with the cost of purchased feeding stuffs has been one of the chief subjects of enquiry (1). A single example of what is happening in an increasing number of cases may be given. A farmer who gets a good wholesale price for his milk, Grade A, who has always kept his cows in good condition, who was always regarded as sound and progressive in his management, used to spend annually about 12s 4d. per cow on lime and mineral fertilisers applied more or less systematically to his fields. Two years ago he agreed as an experiment to increase this expenditure to 46s. per cow. The result was that the combined cost of fertilisers and feeding stuffs in 1930 showed a reduction of 50.3 per cent. on their combined cost in 1929, the prices of feeding stuffs being kept constant for both years. Differences in seasons only slightly modify results. Similar results have been obtained with sheep, although the exact figures are not available.

Seed potatoes.—The high price of seed potatoes is moving farmers to take more systematic interest in the management of seed grown by themselves.

Title of paper issued during the year.

1. ORR, J. : *Grass and hay farming. An economic study.* Manchester Univ. Press.

116. MIDLAND AGRICULTURAL COLLEGE.

Sugar beet investigation.—Reports were sent to the twenty growers who co-operated in this investigation. Details were given showing the allocation of the various costs, together with a comparative statement which showed each farmer how his costs and returns compared with the remainder of the group. Owing to the reduced subsidy given to the sugar beet industry, only nine of last year's farmers are growing beet this year. Records are kept on these farms but no additions have been made to this number.

Meat distribution and consumption.—With the assistance of a grant from the Markets Division of the Ministry of Agriculture a study of meat distribution and consumption in the town of Loughborough was completed during the year under review (3).

Old accounts.—Two sets of accounts, in one instance dating back to 1849, are being analysed. Owing, however, to the pressure of work on more immediate problems it has been difficult to find time to deal adequately with these accounts.

Titles of papers issued during the year.

1. JONES, A.: The organisation of livestock insurance. *Proc. Second Internat. Conf. Agric. Econ., Aug.,* 1930.
2. BRIDGES, A., and JONES, A.: *The Midlands grazing industry.* Clarendon Press, Oxford.
3. JONES, A., and MAKINGS, S. M.: Some aspects of meat distribution and consumption. *Midland Agric. Coll., Survey Studies No. 2.*

117. NEWCASTLE : ARMSTRONG COLLEGE, DURHAM UNIVERSITY.

Poultry management study.—This research project was organised in collaboration with a similar project undertaken by the West Midland and North Western Provinces. Briefly, the object of the survey is to add to knowledge on capitalisation, income, expenditure production and systems of management of poultry enterprises. In the Northern Province it was not found possible to commence the collection of records until the 1st of December, 1930, since when 32 poultry enterprises have furnished economic data on a plan identical with that of the West Midland and North Western surveys. The first accounting period ended on the 30th September, 1931, and as soon as closing valuations have been collected, a report on results during this period will be prepared in collaboration with the West Midland Provinces. The poultry enterprises included in the survey represent a variety of types, and the work has attracted some notice among poultry keepers generally in this part of the country. It was originally hoped that the County Poultry Instructors might give assistance in the collection of records. In fact, however, it was found necessary for members of the staff of the Branch to make regular monthly visits to each of the farms concerned, and in this way the interest of the participants has been maintained and the collection of records has been kept up to date.

For the second accounting period which began in October, 1931, the scope of the survey has been extended and approximately 50 enterprises will be represented.

Preliminary survey of milk production in Durham.—Arising out of a discussion which took place at a conference of Advisory Economists at the Ministry on the question of a proposed national survey of milk costs, a suggestion was put forward that in order to keep the survey within practical limits the producer-retailer and the family farm should be excluded. In view of the importance of these two types in the northern province, a questionnaire survey of milk producing farms in Durham county was undertaken during the summer of 1931. The object of this survey was to provide some measure of the relative importance of these types of producers in the area (i.e., the producer-retailer and the family farm). The method of the survey was to send a simple questionnaire to each farm in the county of Durham, registered under the Milk and Dairies Order, asking for particulars relating to one recent week only (week ending July 31st, 1931). In all, 3,431 questionnaires were sent out. Completed and usable returns were received from 1,175 farms. A further 80 late returns were also received, but these referred to different weeks, and 69 incomplete returns could not be used. A memorandum embodying the results of this enquiry is being prepared for circulation to other advisory centres. Further developments await a decision in the matter of the national costings survey.

The industrial survey.—Early in the year at the request of the Ministry of Labour an economic enquiry extending over the depressed industrial area of the north-east coast was undertaken by the Economics Faculty of the College. The survey was intended to examine the trend of events during recent years with particular reference to the probable course of the demand for labour in the area. While it was understood that specific inclusion of the agricultural industry in the area was not desired, as the Ministry of Agriculture had intimated that they were already well informed on relevant matters, the Advisory Officer has collaborated with the Economics Faculty in the examination of the features of the local agricultural situation to which it was considered necessary to refer.

Title of paper issued during the year.

1. DINSDALE, D. H.: Unemployment in British agriculture. *Le Assicurazioni Sociali* (Rome). Mar., 1931.

118. READING UNIVERSITY.

Cost accounts.—Complete cost accounts for the whole farming enterprise are kept on six farms, having a total area of 2,226 acres. The accounts for four of these farms are now available for a period of seven years. A report (1) on one of these farms was published during the year, and a similar report for another farm is now being prepared for publication.

Enterprise studies.—Three enterprise accounting studies are now in progress. The first is for beef-production on a farm in Hampshire. The second is for poultry on three farms, two in Middlesex and one in

Hampshire. The third is for strawberries on over 30 holdings in the Southampton strawberry district.

Surveys.—A report (2) based on a survey of nearly 300 dairy farms in the Blackmore Vale district of Dorset was published during the year. The field work of two other surveys has been completed, viz. ; a survey of about 100 plantations in the north Berkshire fruit-growing district, and a survey of over 600 strawberry growers in the South Hants. strawberry area.

Financial accounts.—A selected sample of 40 of the dairy farmers surveyed in the Blackmore Vale have been asked to co-operate in the keeping of financial accounts in simple account books specially prepared for the type of farming concerned.

Miscellaneous.—A study of the historical development and the present position of market reporting is in progress.

Titles of papers issued during the year.

1. THOMAS, E. : A Dorset cheese-making and milk-selling farm. *J. Min. Agric.*, **38**, 1, 27, 1931.
2. BISSET, G. B., PRINGLE, C., and THOMAS, E. : Dairy farming in the Blackmore Vale. A study based on conditions in the Sturminster Rural District in 1929. *Survey Studies.* 1. *Bull.* 40. *Univ. Reading. Agric. Econ. Dept.*, 2 maps.

119. SEALE-HAYNE AGRICULTURAL COLLEGE.

Financial accounts.—The accounts of 82 farmers, covering 20,587 acres, were collected, analysed, and reported on during the year.

Sugar beet.—Costs of growing sugar beet were obtained from 18 farmers.

Labour requirements.—Information on the productive man and horse labour requirements of the main crops and types of livestock was collected by the survey method.

Twenty-four farmers completed a year's labour diary.

Data on the manuring of crops were collected by means of a mail questionnaire.

Movements of livestock in Devon and Cornwall.—This investigation was commenced by extracting particulars of each class of livestock received and forwarded monthly at each railway station in the two counties.

Strawberry costs.—A limited number of strawberry growers are keeping records of their costs of production.

Title of paper issued during the year.

1. LONG, W. H. : Milk selling *v.* butter making in South Devon. *Seale-Hayne Coll. Monthly Pamph.*, 10, Feb., 1931.

120. WYE : SOUTH EASTERN AGRICULTURAL COLLEGE, LONDON UNIVERSITY.

Farming costs of production and financial results.—Twenty-six farms were under review, and in addition investigation was made into separate enterprises on several farms (1, 2, 3, 5, 6, 8).

A *food-recording scheme* for dairy cows was introduced on about forty farms in Kent and Surrey in April, 1930, this being the first scheme of this kind to be tried in this country.

Titles of papers issued during the year.

1. Wyllie, J. : Investigation into farming costs of production and financial results. X. Sheep breeding and feeding over six years. *S.E.A.C. Dept. of Economics, Rept. No.* 10.
2. Wyllie, J., and Hewison, N. V. : Financial results on the College farms. I. Sheep breeding and feeding over four years, 1926–27 to 1929-30. *S.E.A.C. Dept. of Economics, Rept. No.* 11.
3. Wyllie, J. : Investigation into farming costs of production and financial results. XI, Costs of production and financial results for potatoes and root crops, 1924 to 1929. *S.E.A.C. Dept. of Economics, Rept. No.* 12.
4. ——— : The economics of machine milking. *Trans. Yorks. Agric. Soc.*, 1931.
5. ——— : Successful milk production. *J. Brit. Dairy Farmers' Assoc.*, 1931.
6. ——— : Some pointers in farm management. *J. S.E. Agric. Coll.* 278, 1931.
7. ——— : A word for cost accounting. *J. Proc. Agric. Econ. Soc.* **1**, 3, 76.
8. Knox, M. A. : Some sugar beet costs and returns. *J. S.E. Agric. Coll.*, 131, 1931.

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121. ABERDEEN : NORTH OF SCOTLAND COLLEGE OF AGRICULTURE.

Financial accounts investigation.—The investigation into the profitableness of farming in Scotland is being continued, and the number of farmers co-operating has been increased. During the year the records have shown that the co-operating farmers have been on the whole greatly affected by the depression, but few have withdrawn from the scheme. The number of farmers voluntarily desiring to join has increased, and more interest in the results has been taken. Each farmer who co-operated in the scheme received a report on the economic position of the farming type to which his farm belonged, along with a report on his own farm. The analytical work on the figures for the past year is now in progress.

Miscellaneous.—The scope of the collection of details of farm management by means of cost accounts has been enlarged, and the investigation into the poultry enterprise has been continued.

122. EDINBURGH AND EAST OF SCOTLAND COLLEGE OF AGRICULTURE.

Financial accounts investigation.—As in previous years, the investigation of farm accounts undertaken in collaboration with the Department of Agriculture for Scotland has constituted the major portion of the work of the Economics Department (1).

No difficulty has arisen in securing the co-operation of as many farmers as could be dealt with. The number of farms studied in respect of the financial year 1929–30 (dealing with the production and sale of the 1929 crop), accounts for which were analysed during the academic year, were as follows :—

Type 1. Border arable-stock farms ..	27
Type 2. East of Scotland crop selling farms	31
Other farms	2
	60

As compared with the preceding year, the number of " other farms " has been reduced to admit of strengthening the two principal types.

Grouping along the general lines laid down in the previous year was continued. A change was made, however, by the division of the holdings of Type 1 (Border arable-stock farms) into separate groups of " low ground " and " higher land," respectively.

The feature of the year was a heavy fall in the profits of the East of Scotland arable farm groups, due to the low prices ruling for main-crop potatoes grown in 1929. The average receipts per acre of this crop grown were £15 15s. 3d. for the 1929 crop, as compared with £27 15s. 4d. for that of 1928. Had the 1929 crop brought the same average price per acre as was received in 1928, the average profit on 21 East of Scotland arable farms would have been considerably higher in 1929–30 than in 1928–29.

The remarkable variation in the results of the individual farms within the same groups—commented upon in last year's report—was again evident.

In order that—as far as possible—the causes of this variation might be traced, the data were analysed experimentally, using both the cross tabulation and multiple correlation methods. The most satisfactory result was obtained with the low-ground Border group of 19 farms. In this case it was suggested that (*a*) profits increased with increased " production " (excess of sales over purchases of the same thing, adjusted for valuation changes), (*b*) profits decreased as the proportion of cattle to sheep became greater, (*c*) profits decreased as the number of extra store sheep bought for feeding purposes increased, (*d*) profits decreased with an increasing proportion of cultivated land. Nevertheless, even with these 19 farms—the largest homogeneous group studied—it was evident that the sample was much too small for satisfactory analysis on these lines.

Two comments upon the work done are in place.

(*a*) A laborious analysis of the data referring to the 19 Border farms pointed to their profits being governed, very largely, by four factors—" production," the proportion of cattle to sheep, the extent to which purchased store sheep were fed, and the proportion of arable land. A mere study of relative index numbers would have suggested the existence and direction, although not the exact extent, of the influence of the last three of these factors.

(*b*) The study of financial accounts may make it possible to explain past results. Explanations after the event are, however, of little value unless they furnish guidance for the future. Forecasting may be dangerous, but it offers greater possibilities of service to the agriculturist than does mere explanation.

Demonstration smallholdings.—With one exception accounts have been completed for all the demonstration smallholdings. Occasional requests for inclusion in this service have been received from other holders, 10 smallholdings now being included. A short report dealing with their accounts is in preparation.

Title of paper issued during the year.

1. WHITTAKER, E.: Some factors in success. 1. Border semi-arable sheep farms in 1929-30. 2. East of Scotland arable farms in 1929-30. *Circulated privately.*

123. GLASGOW: WEST OF SCOTLAND AGRICULTURAL COLLEGE.

Financial accounts investigation.—The number of farms keeping financial records under the scheme for the " Investigation of the profitableness of farming in Scotland " increased during the year to about sixty-five at the end of September, 1931. There were several withdrawals during the year, mainly due to changes in tenancy.

As in previous years, a certain number of accounts was obtained by the co-operation of farm accountants and their help in this respect is gratefully acknowledged. The majority of the accounts are, however, from farmers who had not previously kept any complete financial record, and the method of presenting the completed accounts and the comparative statements prepared appear to be very satisfactory to them.

Poultry farming.—Since October, 1931, a start has been made with accounting on poultry farms, of which there is a good number in the immediate counties. To date 6 farms have commenced keeping records.

At present a total of 75 general and poultry farms are co-operating.

III.

OTHER INVESTIGATIONS.

R.

GRASSLAND.

125. THE IMPROVED MANAGEMENT OF GRASSLAND.

(*a*) WELSH PLANT BREEDING STATION, ABERYSTWYTH.

These researches, which are conducted in conjunction with Professor T. W. Fagan and the Department of Agricultural Chemistry, have been considerably extended. The original strain trials under intensive management which involved three separate experiments (including the " Penglais " experiment which has been frequently referred to in previous reports) and the collection of a vast amount of data have been completed. The preparation of a detailed report is a matter which will take a great deal of time, and owing to pressure of work and the impossibility of publication under present conditions, such a report is for the time being not being proceeded with. It is felt that any form of abridged report would be wholly unsatisfactory in view of the complexity of the issues and the importance of the results obtained. Some of the more important findings have been published incidentally, and the results are being made use of in connection with the planning of further experiments. These investigations have indicated a number of points that demand further critical study—some of which are now under investigation by the Plant Physiologist and others under the more general routine researches of the Station as such. The chief chemical need which the preliminary experiments suggested was to ascertain the effect of various schemes of improved management when conducted on different soil types and at different elevations, and to ascertain the chemical behaviour of the chief species when grown (*a*) in mixtures and (*b*) in pure plots.

With these ends in view the following experiments are now being conducted wholly or in part by means of the grant made available for the purpose.

Manurial trials on selected swards at various elevations.—This experiment is conducted at five centres, under grazing conditions (with sheep) and with six manurial treatments. Yield data, supported by chemical and botanical analyses, are being obtained. The conduct of this extensive trial (now in its second harvest year) would not have been possible without the further financial assistance which the Station received from Imperial Chemical Industries, Ltd. (1).

A comparison of the chemical composition of four grass species.—The species were station pedigree strains and were grown (*a*) in mixtures (with each other and kept weeded) ; (*b*) in pure broadcast plots (kept weeded) ; and (*c*) in drills (kept weeded). In the case of all plots (including the mixtures) the chemical analyses are made on the species separately and on stem and leaf separately.

This experiment entails a very great deal of laborious work, but it is hoped to be able to show to what extent the inherent chemical composition of a particular pedigree strain is influenced by competition.

A comparison of the chemical composition of four grass species and one clover species.—The species were station pedigree strains and were grown on different soils and at various altitudes. Six centres have been used for this experiment, the highest being at 1,000 ft. above sea level. The different lots have been sown in drills (kept weeded) and arranged in plots receiving (*a*) no manure ; (*b*) phosphates and potash ; and (*c*) phosphates, potash and nitrogen.

This research is regarded as of first-rate importance, and the results obtained will be valuable in connection with all the grassland-improvement and grassland-management investigations undertaken by the Station as a whole. It is vitally necessary to obtain information on the extent to which the composition of individual species varies with altitude and type of soil and whether manures influence composition to a markedly varying extent relative to altitude and soil type.

The chemical composition of important miscellaneous herbs.—All our investigations lend emphasis to the fact that the status of a number of important herbs is a matter which will have to be reviewed in the light of modern methods of management and of a better knowledge of their biological and chemical relationship. With a view to assisting in this review chemical analyses are being carried out on a number of herbs at different stages of growth and on contrasting habitats (2).

In this connection it may be here added that Mr. W. E. J. Milton is engaged upon an extensive research on the seasonal palatability and seasonal eatability of the more important of the so-called "weeds" of grassland.

Titles of papers issued during the year.

1. Davies, Wm., and Jones, T. E.: The yield and response to manures of contrasting pasture types. *Welsh J. Agric.*, **8** (In the press).
2. Fagan, T. W.: The influence of management on the nutritive value of herbage plants. *Agric. Prog.*, **8**, 1931.

(*b*) BRISTOL UNIVERSITY.

The experimental campaign outlined in previous reports was continued. In February, 1931, four of the intensively managed plots received applications of phosphatic and nitrogenous fertilisers. The appearance of the manured plots in March was very satisfactory, the grass being fresh and green. By April the plot receiving phosphatic fertiliser in addition to nitrogenous manures had improved to a very marked extent, and the value of phosphate in addition to nitrogen was clearly demonstrated. The intensively grazed and manured plots in comparison with those which had been intensively grazed but not manured were free from "mat" and dead material, and the botanical composition was superior, there being a lower proportion of weeds and moss and stronger growth of the better types of grasses.

Climatic conditions throughout the grazing season were very unfavourable. A dry cold spring was followed by a very wet summer, which, together with the low lying clay soil of most of the experimental area, had an adverse effect on growth. Nevertheless, even under these conditions, the system of intensive grazing provided more feeding material than could have been obtained off the same area under the ordinary extensive practice of the farm. The grazing results obtained and the condition of the plots during the season indicated that more stock than was available on the farm could have been utilised with advantage. This was especially the case on the manured plots. The ragged appearance of many of the plots at the end of the grazing season was undoubtedly due to the lack of suitable stock on the farm.

The yield of milk from the dairy cows grazing on the plots was fairly steady throughout the season and the average yield was considerably higher than that given during the preceding winter months.

During the year under review the Resident Recorder collected the following data in addition to being responsible for the correct stocking of the plots and the maintenance and repair of fences, etc., (*a*) complete grazing records for all plots in cow days per acre ; (*b*) milk yield records ; (*c*) meteorological records ; (*d*) botanical changes in the herbage ; (*e*) 159 herbage samples for chemical examination ; and (*f*) 64 soil samples for chemical examination.

126. PRODUCTION OF SEED POTATOES ON A COMMERCIAL SCALE IN NORTH WALES.

BANGOR: UNIVERSITY COLLEGE OF NORTH WALES

This scheme was planned to determine the possibility of producing seed potatoes on a commercial scale in North Wales. A small scheme, started in 1927, formed the basis of the larger one of the Ministry which followed in 1928. Stocks of the varieties Sharpe's Express, Great Scot and Kerr's Pink were maintained each year, without change of seed, at the fifteen different centres.

1930 was regarded as a critical year in which evidence of degeneration due to virus infection might be expected. Four centres were discarded from the scheme in 1930, but only two of these because of the spread of virus diseases. Of the remaining centres eight contained less than 0.5 per cent. of virus diseases, and two less than 3 per cent. The seed stocks were marketed under a joint scheme arranged by the growers.

In 1931 the stocks were maintained in the same healthy condition and less than 0.5 per cent. virus disease was again recorded. At two of the centres, where less than 3 per cent. was found last year, the amount of infection was reduced to less than 2 per cent. The scheme was extended to other districts in 1930, and eight new centres were added. Of these, six showed less than 0.5 per cent. disease, while two showed a slight increase to 0.94 and 0.81 per cent.

Welsh seed was compared with Scottish seed in a series of yield trials. In the trial at Aber the Welsh stocks gave a significantly better yield than the Scottish stocks. This difference, however, is less marked when the average of the remaining trials is taken into account. The general result of these trials proves that the seed produced under the scheme is at least of equal merit to new seed from Scotland.

127. METHODS OF MECHANICAL ANALYSIS.

BANGOR: UNIVERSITY COLLEGE OF NORTH WALES.

Upward of 100 samples have been received in connexion with this work, which is being carried out by Dr. M. Richardson. The examination of such a large number by different methods entails a very considerable amount of work and is not yet completed. Sufficient data have, however, been accumulated to warrant the recommendation of a modification of the present International method. Gypseous soils have proved rather troublesome, and much time has been spent in devising suitable methods for their analysis. An aluminous soil from New Zealand appears to require a totally different method of treatment from all other soils. In the time at our disposal it does not appear possible to reach an entirely satisfactory procedure for such soils. Lateritic soils, contrary to earlier opinion, do not appear to present any serious difficulties. The remaining work, apart from completion of the routine scheme, consists of the investigation of working details with a view to their simplification.

128. KEMP IN THE FLEECE OF WELSH MOUNTAIN SHEEP.

BANGOR: UNIVERSITY COLLEGE OF NORTH WALES.

A further twelve months' work on this scheme has brought it to a conclusion, though the final results are not available yet, as the lambs born in the spring of 1931 have yet to be examined. It is necessary that the grading and examination of the coats should be deferred until the fleece is almost adult. Its final examination will be completed next spring.

Work was continued under all the heads mentioned in the report for 1929-30. An attempt will be made, when the full results are available, to give a concrete answer to the question raised in Section 2 of that report. A considerable number of sheep have been included in the experiments, and comparatively large numbers can now be used for the statistical analysis.

Laboratory work has been concluded and an account prepared for publication. It is hoped that this will appear shortly. The main conclusion has been established that a definite morphological plan in the arrangement of kemp on the body can be recognised. If two areas on the same sheep are chosen, it is true that in different sheep the amounts of kemp will not be proportional; but a series of points can be taken and will always fall into the same order as regards amounts of kemp. It has been found that an estimate of the kempiness of sheep, based upon an analysis of two points, gives good index figures.

It is found that an arbitrary visual judgment of the kempiness of a fleece, either at a point or taken as a whole, is one of high accuracy. The breeder will undoubtedly be able, with very little practice, to judge the kempiness of his own sheep.

The sorting of fleeces by a manufacturing expert was repeated. In particular, the opportunity was taken of comparing the sorting of fleeces taken from the same sheep in successive years.

The final practical result of the whole scheme of research may be stated simply. In order to secure fleece improvement, the breeder of Welsh mountain sheep should select for three characteristics :—

(*a*) A thick coat at birth. This is necessary as a protection for the lamb at the time of birth

(*b*) Relative freedom from kemp. It is to be noted that characteristics (*a*) and (*b*) are negatively correlated, so that special care would have to be taken to select for both at the same time. The negative association is not an absolute one, and such dual selection does not present any difficulty.

(*c*) Shortness of fleece. This is extremely important, as it is a characteristic that can be readily judged by the breeder himself, and is so closely associated with " quality " as assessed by the manufacturer that selection by the breeder for shortness would produce almost as good results, or quite as good results, as would an attempt to select for fineness directly. It is possible that, to some slight extent, fleece weight might suffer in the selection for shortness. This effect, however, is not likely to be serious, as short fleeces commonly make up to a considerable extent in closeness what they lack in length. In addition, closeness of fleece is a characteristic readily appreciated by the breeder, and one that he can select for.

It is hoped to publish the full results of the complete scheme in the form of a monograph. This will be possible as soon as the experimental lambs of 1931 have been examined.

It is intended to apply the results obtained and to build up a flock on the lines that those results indicate as being the best. In this way a demonstration flock will be available for the examination and criticism of breeders. It is also hoped that this flock will become a source of rams of the desired type. Sixty ewes selected for the three characteristics mentioned above have been mated this autumn (1931) with a ram possessing an exceptionally good fleece.

129. STUBBLE CLEANING.

CAMBRIDGE UNIVERSITY.

The investigation on stubble cleaning was initiated primarily to ascertain the effect (a) on buried weed seeds and (*b*) on mature plants, of superficial cultivation of stubbles. Regarding the buried seeds, an attempt is being made to determine the efficiency of the cultivations in making conditions favourable for their germination; also to determine the extent to which further mechanical treatments are capable of destroying the resulting plants. The problem concerning the mature plants is a simpler one, consisting of finding out how effective various stubble cultivations are in destroying the vegetative plants.

This year the experiments have been more comprehensive than formerly and the influence of the following factors, separately and in certain combinations, has been under consideration :—(*a*) type of implement, (*b*) time of cultivation, and (*c*) type of soil.

The implements that have been tried are the broadshare, cultivator and harrow, which have been used (i) directly after harvest and (ii) after an elapse of 4-6 weeks. Separate experiments have been carried out on heavy and light soils.

Field results.—Results up to date on both light and heavy soil show very definitely that where the soil had been left uncultivated after harvest (control or 00 plots) large numbers of weed seeds, though capable of germinating under favourable conditions, were induced to remain dormant, and that these continued to be viable. In all the experiments even once broadsharing made conditions favourable for a comparatively high percentage of germinable seeds. On further broadsharing, cultivating and harrowing the numbers were increased but more so on light land than on heavy.

Late cultivations on the light land have been outstanding in making conditions favourable for species showing maximum germination in late autumn. On the heavy land this has been less evident; probably due to weathering action on the early cultivated plots being almost as effective in reducing the clods and bringing about conditions favourable to germination as the late cultural operations.

On the light land " seeds " which germinated readily after the cultivations had been done were those of wheat (self sown), *Stellaria media* and *Veronica persica*. *Papaver* spp. showed slight delay in germinating, while *Veronica hederaefolia* did not give maximum germination until early December. On the heavy land wheat, *Stellaria media* and *Veronica persica* have given results similar to those on the light land but in addition *Alopecurus agrestis* germinated very readily. *Alchemilla arvensis* also has shown hardly any delay. *Brassica sinapis* has shown delay but not to the extent of *Veronica hederaefolia* and *Galium aparine* both of which have given maximum germination in early December.

So far the work has shown that periodicity is entirely a peculiarity of the species and is not influenced by the type of soil nor by cultural operations.

In destroying mature plants and in making conditions favourable for germination, the broadshare, of the implements tried, has decidedly given the best results whether used on heavy or light soil, carried out early or late.

Throughout the experiments it has been shown that young seedlings which appeared on the cultivated plots were easily destroyed by subsequent cultural operations. Ploughing has been very effective ; the few that were sometimes left in the crevices were, by a further harrowing, usually completely buried.

The reduction in the seed population of the soil as a result of stubble cleaning has been appreciable in the case of *Alopecurus agrestis*, *Stellaria media*, *Papaver* spp., *Veronica hederaefolia*, *Alchemilla arvensis* and *Galium aparine*.

Although the evidence is, as yet, not adequate for generalisation it may be stated that the results up to the present indicate that some weeds can be controlled to a considerable extent if not completely by stubble cleaning. In these are included two very important weeds, viz., *Alopecurus agrestis* and *Papaver* spp. Also autumn cultivations seem to be effective in destroying vegetative plants remaining in the stubble after harvest. The only ones that are able to survive successfully are the deeply rhizomatose plants, e.g., *Convolvulus arvensis*

Work on individual weeds.—The life histories of *Avena fatua*, *Ranunculus arvensis* and *Allium vineale* are being studied in detail with a view of discovering stages at which control measures are likely to prove effective. " Seeds " of *Avena fatua* and *Ranunculus arvensis* and bulbils of *Allium vineale* were collected in August and September 1930. The investigation commenced with the sowing of most of these seeds and bulbils in lots of a hundred each under different conditions ; others were stored for future sowing.

The work on chlorates.—Sodium chlorate and calcium chlorate at concentration of from 5 per cent. to 15 per cent. have been used along with other chemicals against weeds. The spraying has been at the rate of 160 gallons per acre. Both chemicals have been successful in killing growing plants. Of considerable interest has been the control of hawthorn bushes by 5 per cent. solution of sodium chlorate. The wild onion is the only plant which has been able to withstand a concentration of 15 per cent. and over of sodium chlorate. The foliage of the onion suffered check, but bulbs formed underground and remained in every case undamaged ; in November, 1931, these developed into healthy plants.

An attempt was also made to add a wetter and spreader to the chlorate solution so as to get contact with the waxy onion foliage but the results were not satisfactory.

130. GOOD AND BAD FIELDS OF WHEAT.

CAMBRIDGE UNIVERSITY.

This is the final report for the period of the grant, which ended on the 30th September, 1931.

As in the two preceding years, the work took the form of an investigation into the effects of nitrogenous dressings applied to wheat at different periods of the year ; and, as before, arrangements were made for the investigation to be done in Norfolk, in Hertfordshire, and in Cambridgeshire. For experimental work in general, and for work on nitrogenous fertilisers for wheat in particular, the year was climatically disastrous. Nevertheless, the investigations in all three places were carried through, and an analysis of the data is now being made. Until this is complete, it will be impossible to summarise properly the results obtained from the three years' work.

It is already evident, however, that the problem has not been completely solved. There are two reasons for this. First, the difficulties of weather ; in the first year prolonged frost was followed by severe drought, while the remaining two years were exceptionally wet. This wetness caused exceptional growth of straw and thereby bad " lodging " on the heavily dressed plots ; and, further, it brought an unusually severe attack of fungi of the " white head " group.

A second reason why three years' work has not brought finality of result lies in the sharp differences of reaction displayed by the various soils concerned. Much valuable experience and data have, however, been obtained, and with the help of this the work will be able to be continued for one or two years more on a smaller scale, but in a more critical manner and without any special outlay. In fact, the logical continuation of the experiments has been incorporated into the ordinary programme of husbandry investigations undertaken by the Post-Graduate Agricultural School of the University.

Unexpected difficulties have stood in the way of the really successful co-operation which proved to be possible in the first year of the work. No blame attaches to any of the Stations concerned for this, and on the whole it may be said that the whole enterprise has been successful.

131. *SPARTINA TOWNSENDII* (RICE GRASS) IN ESSEX.

ESSEX COUNTY COUNCIL.

At all centres where there has been successful establishment prior to 1930, increased growth of plants has been recorded. The amount of growth is greatest on the higher levels and in the more sheltered situations, where the average annual increase in diameter varies from 1½ ft. to 2 ft. It is least in the lower and more exposed parts, in which some plants have remained practically constant in size or have increased by only a few inches.

Investigations into the causes of the failure of plants to establish themselves in apparently likely situations have been continued. Tidal scour is suspected to be an important factor in this connection, and an instrument to give a measure of the rate of tidal flow has been designed and constructed. This instrument has been tested and is likely to yield information on the point after certain minor modifications have been made.

There have been indications that the salinity of the sea water may also have a bearing on this matter, but salinity alone would not account for some of the failures.

The results of germination tests tend to confirm previous findings. The period of vitality does not appear to extend for more than four months. After the second month there is a rapid and large decline in the rate of germination. In one case, which is typical, seed set immediately after gathering germinated 90 per cent. ; the next lot set one month later germinated 74 per cent. ; the next after two months 62 per cent. ; the next after three months 8 per cent. ; and the last after four months 0 per cent.

Interest abroad in *Spartina Townsendii* shows no signs of abating. Plants and cuttings have been sent to India, Sarawak, Antigua, and Australia (four consignments), and seed, by special request though not advised, to New Guinea, New South Wales and Honolulu.

At home the East of Scotland College of Agriculture have taken 5,000 plants for use on the Tay, while the Holkham Estates, Norfolk, have received 10,000. In the former case the object in view is reclamation, in the latter to improve the grazing quality and stock-carrying capacity of salt marshes.

Titles of papers issued during the year.

1. Oliver, F. W., and Bryce, J.: Further notes on the economic possibilities of rice grass. *J. Min. Agric.*, **38**, 8, 798, 1931.
2. Oliver, F. W., Bryce, J., and Knowles, F.: *Spartina Townsendii* (Rice grass). Its economic possibilities. *Min. Agric. Misc. Pub., No.* 66.

132. INVESTIGATION OF BULB DISEASES.

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY.

Narcissus bulbs in cultivation exhibit a number of diseases affecting the bulbs and roots. Among these may be mentioned eelworm disease due to *Tylenchus dipsaci*, various diseases due to insects, a disease due to *Botrytis narcissicola* which usually shows black sclerotia on the papery bulb scales, basal rot which is frequently associated with the presence of *Cylindrocarpon radicicola*, and a bulb rot due to *Fusarium bulbigenum*. In this investigation it is only the last named disease that has been fully studied.

The bulb rot caused by *Fusarium bulbigenum* is common in stored bulbs and there is evidence of its occurrence in the field. It starts as a brown discoloration of the region of the basal ring. The bulb becomes soft at this spot and the rot spreads through the base and up the scales. Softening is accompanied by a pronounced dark discoloration of the affected tissue, usually a chocolate-brown, but sometimes a brick-red or even a bright violet in certain bulbs of the variety Loveliness.

F. bulbigenum was isolated from a large proportion of the rotting bulbs and from a large number of varieties and its cultural features studied, two strains being observed. The disease was produced by inoculation of bulbs from a pure culture of the fungus, but in the majority of cases success was only obtained when inoculation was through a wound. Marked differences were found in the percentage of infection shown by different varieties, and this difference of resistance was confirmed by a study of the " rate of invasion " of separate bulb scales. Twenty-two varieties were investigated in this way, and it was found that the progress of attack varied from 0.2 mm. per day in resistant varieties to 3 mm. a day in the susceptible White Trumpet. Inoculations of roots failed to produce the disease.

Control methods.—It is held by certain growers that early planting of unaffected stock will markedly reduce the number of bulbs lost by Fusarium rot but an experimental test of this belief gave it no support. As was to be expected, unfavourable conditions in storage such as high temperature and high humidity were found to increase the rate of development of the disease in an infected stock. With healthy bulbs, however, conditions of high temperature and high humidity did not bring about decay.

An investigation was made of the effect of surface sterilisation of bulbs on the incidence of the disease. Untreated bulbs were compared with those subjected to the hot water treatment for eelworm, and with those similarly treated but with the addition of formalin and uspulum to the water. There was evidence that the surface sterilisation brought about by these fungicides was effective in reducing rot during storage. It was found that suitable concentration of formalin such as 0·125 per cent. could be employed without injury to the bulb. Evidence was obtained in agreement with the work of Weiss that the hot water treatment may under some circumstances increase the spread of the disease.

The results of the work have been prepared for publication.

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133. BLACKENING OF POTATOES AFTER COOKING.

LONDON UNIVERSITY: KING'S COLLEGE OF HOUSEHOLD AND SOCIAL SCIENCE.

It must be stated at the outset that practically all the results so far obtained have been negative as regards the solution of the problem as to how to prevent blackening, except by the use of reagents which could not ordinarily be employed (1). One possibility, however, remains to be investigated which may throw some light on the subject, namely, the amount and nature of the iron compounds in the soil in which the potatoes are grown. A considerable amount of evidence has been obtained in support of the view that blackening after cooking is dependent on the presence in the potato of compounds of iron in addition to substances detected by the nitrous acid test. Some King George potatoes, which blacken badly after cooking, have just been obtained, together with a sample of the soil in which they are grown. Some of the same seed potatoes grown in another district have given very good results. Samples of the two soils will be compared as to iron content, etc.

The problems which have been investigated are as follows:—

The nitrous acid test.—Experiments were undertaken with a view to improving the method of applying this test, especially with reference to its use quantitatively. Alternative ways of carrying out the test were devised, but so far the only satisfactory way of comparing the results obtained at different times with various potatoes is the very laborious one of making a water-colour painting of the section of potato after applying the test.

Attempts to compare the colour extracted with that of a standard solution of a coloured substance have so far been unsuccessful.

Very little progress has been made with regard to the investigation of the nature of the substance responsible for the colour obtained in the test.

Determinations of nitrogen in various portions of potatoes showing differences in the test have not given results of any value.

The effect of temperature on the amount of colour produced has been investigated, and it has been found that a low temperature favours the formation of the coloured substance.

Cooking tests.—A very large number of tests has been made using glass vessels, aluminium, enamelled and chromium plated saucepans, but no results of special interest have been obtained.

Knives made of various metals have been used for peeling the potatoes, but again the results so far obtained are not conclusive.

The effect of different waters on the colour of potatoes after cooking.—Samples of soft and hard waters have been employed, but, as was expected, the only difference noted is when the water is on the acid side of neutrality. The results are then better than with a water which, like ordinary tap water, is on the alkaline side of neutrality. A soft water which is alkaline appears to give results which are no better than those obtained with a hard water.

Autoclave tests.—Some potatoes which blacken after the ordinary process of cooking were cooked in an autoclave up to +50 lbs. pressure. It was thought that possibly the substance responsible for the blackening might be destroyed at the higher temperature thus obtained. The results obtained in these experiments have been contradictory; sometimes better results were obtained but not always.

Effect of maturity on blackening.—Some Majestic potatoes similar to those used last spring in the work on this subject, and which blackened badly after cooking, were planted in neutral soil at Northwood, Middlesex, on May 1st. At the beginning of July some potatoes were taken from the roots and examined by the nitrous acid test and by boiling. Very little colour was obtained in the test and no blackening took place after cooking.

Some of the potatoes were lifted and tested at fortnightly intervals, and the remainder were lifted at the end of September. Very little blackening was noted even with the mature potatoes, but some of these potatoes are being kept to see if blackening after cooking increases with time of storage.

In the coming season it is hoped to make further growing tests, and to use soils treated in different ways.

Title of paper issued during the year.

1. Tinkler, C. K.: The blackening of potatoes after cooking. *Biochem. J.*, **25**, 3, 773, 1931.

134. MOLASSES BEET PULP ENQUIRY.

The investigations into the use of molassed beet pulp as a food for cattle, which were initiated in 1929, were continued during the 1930-31 season. The second season's work comprised investigations into the relative values of plain (dried) and molassed pulp (as compared with oats) for the fattening of store cattle and baby beef; the use of molassed pulp, both in the wet and dry state, in the feeding of milking cows; and biological and chemical research into the problem of molassed beet pulp as a possible source of "fishy" taint in milk.

Five centres were engaged upon the enquiry, as follows:—

Feeding to store cattle.—School of Agriculture, Cambridge.

Feeding for baby beef.—Herts. Farm Institute, Oaklands, St. Albans.

Feeding to dairy cows.—Staffs. Farm Institute, Penkridge, Stafford.

Taint investigation.—Midland Agricultural College, Sutton Bonington. National Institute for Research in Dairying, Reading.

The research carried out at the Cambridge School of Agriculture and the Herts. Farm Institute during the two seasons has established that for all practical purposes molassed beet pulp and plain (dried) beet pulp are of equal feeding value, lb. for lb., with crushed oats in the rations of both store cattle and baby beef, and produce carcasses of equally satisfactory quality. 1 cwt. of molassed beet pulp has also been proved by the experiments at the Staffs. Farm Institute to be equal to 1 cwt. of crushed oats in the production ration of dairy cows, while in the maintenance ration 8 lbs. of the pulp soaked with $3\frac{1}{3}$ gallons of water is equal to 56 lbs. of chopped mangolds. The rations are equal in value both as regards milk yield and live weight of the animal, and no variation as between the two is evident in either the butter fat or solids-not-fat content of the milk.

The investigations into the problem of taint have not yet reached a stage at which it is possible to give any definite ruling, and it has been decided that further fundamental chemical and biological research should be conducted at the Midland College and the National Institute for Research in Dairying.

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135. FLUCTUATIONS IN NUMBERS OF WILD RODENTS.

DEPARTMENT OF ZOOLOGY AND COMPARATIVE ANATOMY, OXFORD UNIVERSITY.

Research was continued upon two aspects of the problem of fluctuations in the supplies of Canadian fur-bearing and game animals. The ten-year cycle in numbers of snowshoe rabbits and furbearers in the Canadian forests has been elucidated by the study of data obtained through the Hudson's Bay Company. This problem was fully discussed at the Canadian Conference on Ecological

Cycles, at Matamek River, Canada, in the summer of 1931, which was partly organised and was attended by Mr. Elton, as scientific representative of the Hudson's Bay Company. Publication will be in book form in 1932.

The second aspect of fur-cycles concerns the arctic fox, an important commercial fur. This has a four-year cycle, and is bound up on the one hand with cycles in numbers of the lemmings, on which the foxes live, and on the other hand with epidemic diseases (which are communicable to dogs, and form an important economic loss in the Canadian Arctic). Mr. Elton visited north Norway in the summer of 1930 to study the periodic cycle of lemmings and mice, then at its height. A study of the dog and fox disease, carried out through the Hudson's Bay Company's organisation, has been sent in for publication (1). A general co-ordination of the literature on wild animal epidemic diseases has also been published (2).

In the British Isles, Mr. Middleton has continued and extended his research on the American grey squirrel (3), attention being paid to the occurrence of epidemic diseases which broke out among squirrels during 1930-31, and to damage by squirrels in agriculture and forestry (4, 5). The four-year vole cycle in the British Isles has been followed up by enquiries and field census observations (6). An investigation of the natural fluctuations in wild hares and rabbits in Great Britain was begun, and widespread evidence of epidemic disease was obtained.

A stock of lemmings has been bred successfully in captivity, and in summer out-of-doors also, in order to form the basis of experimental work during the next two years.

Titles of papers issued during the year.

1. Elton, C.: Epidemics among sledge dogs in the Canadian Arctic and their relation to disease in the Arctic Fox. *Canad. J. Research*, **5**, 673, 1931.
2. ———: The study of epidemic diseases among wild animals. *J. Hygiene*, **31**, 435, 1931.
3. Middleton, A. D.: *The grey squirrel.* Sidgwick and Jackson, Lond., 1931.
4. ———: Damage to forests by squirrels. *Q. J. Forestry*, Oct., 1931.
5. ———: The grey squirrel. *Empire Forestry J*, **10**, 14, 1931.
6. ———: A further contribution to the study of cycles in British voles (*Microtus*). *J. Ecol.*, **19**, 190, 1931.

136. INVESTIGATION OF BREEDING SEASONS IN FIELD MICE.

DEPARTMENT OF ZOOLOGY AND COMPARATIVE ANATOMY, OXFORD UNIVERSITY.

The experimental and observational work has been completed and the results are being analysed.

The most interesting result obtained is a proof that these mice scarcely breed if only exposed to nine hours of light each day, while exact controls which have fifteen hours of light each day breed continuously.

The effects of temperature and food have also been studied, and it has been found that there is scarcely any breeding at winter temperature, even though summer food and fifteen hours of light daily are provided.

The curious discovery has been made that the mice breed much faster on winter food than on summer food. Since they do not breed in the wild state in winter, it seems certain that food is not a limiting factor in their breeding season.

For two years forty or more mice have been received each month from Aberdeenshire, and the same number from Roxburghshire and Merionethshire. These three counties are situated in a North and South line at about the same distance from one another. A routine study of the reproductive organs of each of these four thousand mice has been made which will enable a complete account to be presented of their breeding seasons in nature, and the effect of latitude on them.

The results of these investigations are being published in a series of papers in the Proceedings of the Royal Society.

137. RESEARCH IN ECONOMIC ORNITHOLOGY. (INCLUDING THE OXFORD BIRD CENSUS).

DEPARTMENT OF ZOOLOGY AND COMPARATIVE ANATOMY, OXFORD UNIVERSITY.

It has been decided to concentrate on the study of the rook in the Oxford district, and, if opportunity allows, to make a survey of nesting sites of the house martin, in addition to continuation of activities of the Oxford Ornithological Society in the periodic counts of the birds on certain areas and the ringing of as many birds as possible in the district.

The desirability of evolving a satisfactory technique for deciding the status of any bird from the agricultural standpoint is being borne particularly in mind.

During the winter rook roosts and the lines of flight to them were studied. Two counts of birds flying into the Chislehampton roost were made and on both occasions between 5,000 and 6,000 birds were counted, of which probably 4,500 were rooks. The nesting population of the rookeries contributing to this roost in 1928 was 5,100. It is therefore probable that the summer and winter populations are the same.

During the spring an area of 910 square miles, including parts of six counties, was surveyed for rookeries and in April a census was taken. 30,382 nests were counted or 33·38 per square mile. 68 per cent. of the nests were in elms, 11 per cent. in beeches, 9 per cent. in oaks, about 3 per cent. each in scots pine, ash and horse-chestnut, 2 per cent. in 19 other species added together.

In the area surveyed in 1928 most of the rookeries show a small decrease in numbers, but this is more than compensated by large increases in a few. The population has probably increased by about 200 breeding pairs or about one extra nest per square mile.

A census of martins has been made in an area of 56 square miles round Oxford and showed about 12 nests of the house martin per square mile and about 5 of the sand martin. During the year 998 birds were ringed in the Oxford district and 131 at Holy Island, Northumberland, during an expedition at the end of September.

A census of Temple Farm, Sandford, has been made on 12 occasions and of the South Parks area once

The results of the winter census of an area of 125 acres on the farm have been worked out. 25 counts spread over 5 winters gave the average density as 2 birds per acre. An average of 4 in October fell steadily to 1¼ in March.

Surveys have been made of breeding pairs of stone curlews, wheatears, redshank, and snipe near Oxford, and a census made of nesting birds on Temple Farm, Sanford.

In connection with the national census of great crested grebes, numerous lakes were visited in several English counties and a complete survey made of the lowland lochs in S.W. Scotland.

Various types of bird traps have been experimented with and a second trapping station established in the museum grounds. Over 700 birds have been ringed, many of them have repeated their visits, and there have been a few recoveries of birds ringed in earlier years. A few homing experiments with greenfinches showed that birds returned to the trap before they had formed a "trap habit," indicating that it was the locality from which they had been removed to which they returned, not the trap itself.

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138. TRIALS OF HARDY FRUITS FOR COMMERCIAL PURPOSES.

ROYAL HORTICULTURAL SOCIETY AND MINISTRY OF AGRICULTURE.

Varieties representing all kinds of hardy fruits under trial at the Central Station at Wisley now total 275 ; omitting some twenty-seven varieties that have been eliminated from the trials—after adequate test—as unsuitable for wide commercial planting. In the past year further varieties have been selected for extended trial at the substations at East Malling, Cambridge, Long Ashton, Ellbridge (Cornwall), Perdiswell (Worcester), Emneth (Norfolk), Wisbech, Osgodby (Yorks), and Houghall (Durham). It is proposed to establish a substation at the Kent Farm Institute, Borden, for tests of new varieties of cherries. Valuable evidence is being collected upon the suitability of varieties for growing in different districts and for special markets.

Varieties of all "soft" fruits and plums are being tested for their canning value, and the outstanding new varieties among the many tested are, of raspberries, "The Ellis" and Norfolk Giant; of plums, Early Laxton; of black currants, Davison's Eight; and of red currants, Laxton's No. 1 and Earliest of Fourlands. So far no new variety of strawberry has given such good results as Sir Joseph Paxton.

Of the apples to reach good bearing age in these trials, the most promising are Laxton's Superb, St. Cecilia, Monarch, Crawley Beauty, Herring's Pippin and Millicent Barnes. Many of the new apples received from Canada, America, Denmark, and Sweden, and numerous seedlings raised in this country are now fruiting and giving interesting results.

The experiments designed to ascertain the approximate number of bushes required to give a close approximation of the yield of a given variety of black currant continue at Wisley, Long Ashton, and East Malling, and interesting results are being obtained. The acreage occupied by the trials at Wisley is now aproximately 22 acres; and in addition a large area is occupied by the collection of varieties of all kinds of hardy fruits maintained by the Royal Horticultural Society for the purpose of comparisons and synonymy.

Titles of papers issued during the year.

1. ROYAL HORTICULTURAL SOCIETY: Black currants at Wisley. *Gard. Chron.*, **90**, 2326, 74, 1931.
2. ————: Raspberries at Wisley. *Ibid.*, **90**, 2327, 95, 1931.
3. ————: Plums at Wisley. *Ibid.*, **90**, 2331, 178, 1931.
4. ————: The commercial fruit trials. *Ibid.*, **89**, 2305, 170, 1931.

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139. PLANT BREEDING WORK ON BROCCOLI.

SEALE-HAYNE AGRICULTURAL COLLEGE.

The work was commenced in March 1928 at the suggestion of representatives of the Ministry of Agriculture and of the Cornwall County Council, and for the following reasons :—

(*a*) Extreme differences existed between various strains of broccoli generally grown in West Cornwall as regards their suitability to the growing and marketing conditions in that area.

(*b*) The Roscoff strain introduced 1924-26 promised to be the most suitable in type, but stocks already seeded in Cornwall proved to be severely "mixed" owing to hybridisation with the native Cornish strain and to inadequate rogueing of seed crops

(*c*) The Roscoff strain proved to have a very limited period of maturity and was only suitable for mid-season use in the industry.

Commercial stocks of seed and mature plants of the Roscoff strain have been drawn from all parts of Cornwall and from Devon and Dorset, and a method of individual or pedigree selection has been developed by means of which every plant is subjected to progeny tests before being used to build up a strain.

Of 63 strains tested at 11 centres in 1929-30, two mid-season stocks, one early and one late stock, have proved to be definitely superior to existing commercial strains. Sufficient mother seed has been obtained for a process of mass seeding in the coming season. This seed will be distributed in conjunction with the Ministry of Agriculture.

In addition to obtaining, up to the present, four valuable strains, information has been obtained on certain points connected with the crop.

(*a*) The much advocated method of self-pollination as a means of strain improvement has been found to be misleading in its results and injurious to the stock except when employed in a detailed scheme of plant breeding.

(*b*) " Curliness " has been found to be dominant to " plainness " of the leaves in broccoli crosses and by the development of plain-leaved Roscoff strains all Cornish crosses could be eliminated from seed crops in the first generation, thus preventing serious deterioration of the stock.

(*c*) There is a definite relation between certain types of plant and their period of maturity. By the selection of these types rapid progress can be made in the building up of definitely early and late Roscoff varieties.

(*d*) The cultural conditions for the crop in Devonshire have been well worked out and excellent returns have been obtained under Devon conditions.

During the progress of the work many " improved " commercial stocks have been placed on the market and have been tested, but the position in the industry is unchanged except that there has been an increase in the number of so-called Roscoff strains of Italian or Angers type which have been introduced to overcome the difficulties of season of maturity.

Further plant breeding work for a period of 3-5 years will be required to " fix " and " mass seed " a complete range of first early to dead late strains of the best type, whilst the importance of obtaining two or three dead late types has been increased by recent legislation.

140. EFFICACY OF CHLORATES AS WEED KILLERS.

NORTH OF SCOTLAND COLLEGE OF AGRICULTURE.

Trials were started during the autumn of 1930 with a view to ascertaining the value of chlorates in eradicating certain pernicious weeds. Those selected were mostly perennials difficult to exterminate by cultural or mechanical means, and include thistles, docks, coltsfoot, couch (*Agropyrum*) comfrey, sheep's-sorrel, nettles, gout-weed, creeping-buttercup and, amongst the annuals, chickweed and groundsel.

The weeds have been treated under diverse conditions, such as on pasture, on stubble, and after ploughing, Applications have been made at different times in order to find the season most suitable for treatment. The chemical has been applied in powder form and in solutions of various strengths (chiefly 2½ per cent. and 5 per cent.).

In a number of the trials the results were so promising that it was thought desirable that further and more extensive tests should be made. The effect of the application of chlorate on subsequent germination in the spring has been noted.

During the current year, operations have been considerably extended to confirm previous results and more particularly to decide what quantities were most suitable under varying conditions, and to solve other problems arising when dealing with considerable areas infected with weeds.

Further, an attempt is being made to investigate the nature of the chemical changes which take place in the soil due to the application of chlorates.

141. BRACKEN INVESTIGATION.

GLASGOW: WEST OF SCOTLAND AGRICULTURAL COLLEGE.

Factors influencing incidence of the disease.—From daily records of a battery of thermometers and a thermograph there is good evidence that the so-called "disease" of hooked bracken is really a blackening produced in May and June by frost and quite distinct from the true disease, which generally appears later in the season and all over the frond. This latter appeared when there was no evidence of frost. It was noteworthy and deserves further investigation that, while the farmers reported "ground frost" at daybreak during some days of June, our instruments at 3-4 inches above the soil recorded no frost.

Certain experiments suggest that water-sodden soil is the most prone to disease and that drainage in mildly diseased areas leads at least to partial recovery of the bracken. The necessity for the extermination of bracken going hand in hand with drainage is therefore obvious.

Much laborious work has been accomplished in digging profiles in diseased and in healthy patches of bracken and in mapping the types of soil in which rhizomes exist, their depth and positions, occurrence of pan, degrees of acidity etc. These have later been connected up with borings to illustrate soil conditions and observations of the various types of vegetation along these regions. From a study of these data it is hoped to get helpful suggestions.

An investigation into the acidity of the water supplies shows that the streams are alkaline in summer when small, but acid when in spate from surface drainage, so beneficial results of flooding would occur when the water was scarcest.

Experiments to spread disease in the field.—These were made by transplanting blocks a yard square or more taken to such a depth that all the rhizomes were included and transferring them by a horse-drawn sledge to healthy areas sometimes nearly 800 yards away. These were taken from an area which was known to be diseased in 1929-30, and accessibility was a point in their favour, but it was observed that they were not so markedly diseased in 1930-31 as many other areas. Eight transplants were taken and of these seven have so far given negative results and one a not very definite positive result.

Experiments were also made to discover if, for example, etiolation of the fronds would make the fronds more susceptible to infection, but the results are negative.

Experiments to promote pasture on areas lately cleared of bracken.—The continuation of the manuring experiments of the previous year showed the great benefit derived from lime and lime with potash.

Following upon the experiments of 1929-30, bare areas, still containing the dead rhizomes of 1928, were forked over, dressed with various manures, and then sown out with single species. The limed areas alone possessed living specimens in any number by autumn illustrating the waste of seed sown on unlimed land of this peaty nature. Sweet vernal, Yorkshire fog and fiorin were the most successful native grasses but Falkland tussac grass, from the Falkland Isles, promises exceedingly well and looks best of all. Basic slag (10 cwts. per acre) also gave a good result. In an attempt to evolve a method which would not be prohibitive in cost for land of the type experimented on, experiments were laid down with fiorin stolons as carried out in Ireland a century ago on peat bogs but the frosts of last winter took a heavy toll of many of these before they had a good hold. The plants look more satisfactory now.

Other activities.—Considerable work has also been done in collecting data regarding weights of sodium chlorate which are necessary for bracken extermination and the most suitable times. 1½ cwts.

in July or August does little harm to the underlying herbage, but earlier in the year ruins it. A heavier dressing is necessary if one wishes to ensure the death of every frond in one application.

Experiments are also in progress to test whether, as often is asserted, fronds "bleed" extensively if cut while in the "hook," and to check cutting periods for the west of Scotland.

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142. BACTERIAL FLORA IN COWS' MILK.

GLASGOW: WEST OF SCOTLAND AGRICULTURAL COLLEGE.

Of all the common non-pathogenic contaminants of milk the coliform bacteria are recognised to be the most important, and their prevalence is being generally used for the grading of milk. The coliform group comprises a large number of organisms, many of which occur commonly in animal excrements, while others are less frequent in such matters although fairly common in soil and even on grain and other foodstuffs.

The preliminary work consisted of an examination of the records of the Bacteriology Department. The examination of the results of 13,583 samples revealed the fact that there is a marked correlation between the total bacterial content of milk and the occurrence of coliform bacteria. Samples of milk containing coliform bacteria gave generally a much higher bacterial content than those containing no coliform organisms.

The prevalence of such organisms in milk was then considered. Of 13,103 samples, 47 per cent. did not contain coliform organisms in 1/10 c.c., 21 per cent. contained them in 1/10 and 1/100 c.c., but not in 1/1000 c.c. and 18 per cent. contained them in 1/1000 c.c. Several factors are responsible for the occurrence of these bacteria in milk, the most important being the degree of care exercised by the farmer and his workers in the handling and care of the milk. This is clearly shown by the examination of the records. When pure milk tests have been carried out for several years a high standard is attained by the farmers, and as a result a very large proportion (in some cases 100 per cent.) of the samples yield no coliform organisms.

The effect of season of the year on the coliform content was studied. It was found that the proportion of samples containing these bacteria is lowest during the winter months, increases during the spring, and reaches a maximum in July, August and September. It would appear that this seasonal result was largely due to the effect of atmospheric temperature, there being a marked correspondence between graphs showing the proportion of coliform positive samples and the variation in mean atmospheric temperature.

Tests were carried out to determine the different types of coliform bacteria which occur in milk. Three hundred and sixty cultures of these organisms were isolated from 158 samples of milk during the period of five months (December to April). These cultures were subjected to the elaborate series of tests required for their identification according to McConkey's scheme of classification with the following results :—

Type (1) 23 ; (4) *B. Grunthal* 11 ; (5) *B. vesiculosus* 4 ; (7) 12 ; (23) 1 ; (33) 1 ; (34) *B. coli communis* 45 ; (69) 4 ; (71) *B. coli communior* 100 ; (72) *B. neapolitanus* 4 ; (74) 6 ; (101) 6 ; (102) 6 ; (103) *B. lactis aerogenes* 7 ; (105) 1 ; (106) 17 ; (108) *B. cloacae* 26 ; (109) 4 ; other types (A) 6 ; (B) 7. Yet to be identified 67.

15·7 per cent. of the organisms identified were of the *B. coli communis* (No. 34) type ; 35·0 per cent. of the *B. coli communior* (No. 71) type. Therefore 50·7 per cent. of the cultures identified belong to these types which are the common coliform organisms of the intestine.

BACTERIAL CONTENT OF MILK. THE RELIABILITY OF METHODS OF ESTIMATION.

In determining the bacterial content of milk by the plating method, an error may occur due to the bacteria being unevenly distributed in the milk, in the dilution water, and in the nutrient medium used in the test. Numerous experiments have been carried out to determine the extent of this error and the measures which may be adopted to reduce it. Duplicate examinations were made and in many cases even 10 or 50 duplicates were reviewed. It was found that with certain samples of milk the duplicate tests gave quite uniform results, while in other cases there was a wide variation. Thus of 91 samples tested 65 belonged to the former class and 19 to the latter. Further experiments were then carried out to determine the factors responsible for such variation.

The following variations in the procedure were made :—

(*a*) *Amount of agitation the milk and dilution water received during the test.*—The amount of agitation to which the milk and dilutions were subjected in carrying out the routine tests was shown to be quite sufficient. There was no increase in uniformity of results when the milk was agitated for over an hour, and in many cases there was no marked increase in bacterial count.

(*b*) *Age of sample.*—Experiments show that the age of the sample has little or no influence on the uniformity of the results. Many old samples gave irregular results, while others were remarkably uniform, even more so than when the same samples had been tested earlier.

(*c*) *The effect of milk constituents, especially fat.*—Separated milk gave no more uniform results than cream or whole milk.

(*d*) *Effect of temperature.*—Experiments were carried out with the milk and dilution water at various temperatures. There was, however, no marked difference in the uniformity of the results.

(*e*) *Extent of contamination.*—In the case of milk a few hours old, samples with a low bacterial content gave more uniform results than those with a high content.

(*f*) *The kinds of bacteria present.*—Some organisms tend to occur singly or in pairs, others in chains or clusters. The distribution of bacteria in a sample will tend to be more uniform in the former case than in the latter. In this connection experiments are still being carried out with pure cultures of germs isolated from milk. Thus the explanation for the variability which may occur in duplicate estimations of the bacterial content of a given sample of milk has not yet been ascertained. One result which appears clearly from the work overtaken is that in a certain proportion of samples of milk the ordinary method of estimating the bacterial content may yield highly misleading results.

Since October the investigation has been continued with special reference to the coliform bacteria met with in milk. Four hundred and fifty cultures have been isolated from milk samples during the months of June to November inclusive. These are now being identified so that a comparison may be made of the types of coliform bacteria occurring in milk under winter and summer conditions.

143. STRINGHALT, SHIVERING AND ALLIED CONDITIONS IN THE HORSE.

ROYAL (DICK) VETERINARY COLLEGE, EDINBURGH.

Five horses suffering from shivering have been examined post-mortem since reporting a year ago, three being young horses, 3, 2 and 1½ years respectively.

In addition a considerable number of horses suffering from chronic arthritis but not shiverers has been similarly examined.

The further evidence gained goes to support the tentative conclusion mentioned in last year's report that the clinical sign " shivering " is merely a local manifestation of a generalised disease affecting the horse in which the joints and bones are the chief sufferers, and it can now be stated that very definite microscopic changes are present in the peripheral nerves.

Altogether 16 horses suffering from shivering and/or stringhalt have been subjected to post-mortem examination and a case not affected to some extent with arthritis is still to meet.

Microscopic investigations are being made not only of the nervous system but also of all the chief tissues of the body of every horse now destroyed, and a permanent collection of about 1,000 mounted histological specimens has already been prepared ; but this evidence still requires considerable study.

A large number of joints in the fresh state have been preserved and mounted in museum jars as permanent specimens of arthritis.

A small museum has been arranged in a separate room consisting of these specimens, together with representative specimens of bones from the same animal which have been boiled out.

Title of paper issued during the year.

1. Mitchell, W. M.: The problem of unsoundness in the horse. *Vet. Rec.*, **11**, 45, 1126, 1931.

144. DENTITION OF PIGS.

ROYAL (DICK) VETERINARY COLLEGE, EDINBURGH.

The total number of specimens now available for the purposes of this investigation amounts to 675, of which only very few remain to be examined.

There is now no doubt that existing rules relating to the determination of the age of pigs from the state of the dentition require radical revision, if indeed they are of any practical value whatever.

145. INFLUENCE OF FEEDING ON THE BLOOD AND MILK OF DAIRY COWS.

Dr. J. F. TOCHER.

The investigation into the influence of feeding on the composition of the blood and milk of dairy cows was conducted on several dairy herds, (*a*) a commercial herd in Aberdeenshire, (*b*) a herd of pedigreed Ayrshire cows, (*c*) a herd of pedigreed Ayrshire cows (tubercle free), and (*d*) a small herd of cross-bred cows. The constituents analysed in the case of bloods were ash, freezing point, glucose, phosphorus, calcium, urea nitrogen, fibrinogen, albumen, globulin, non-protein nitrogen and total nitrogen; and in the case of milks the constituents analysed were ash, freezing point, lactose, fat, solids-not-fat, casein, albumen, globulin and total nitrogen. Up to the present the work done on the composition of milk shows that cows fed on a wide albuminoid ratio tend to give lower proportions of solids-not-fat generally, a lower proportion of lactose in particular, but a higher proportion of albumen. The results of analysis generally are being submitted to statistical examination. It has been found that, despite feeding on a carefully devised full ration, individual members of a herd of cows selected specially for butter fat, will yield, from time to time, milk poor both in butter fat and solids-not-fat. The effect of grass feeding was studied both on "tubercle-free" cows and on "reacting" cows. It was found that there was very little change from day to day in the quality of the milk from tubercle-free cows. On the other hand, reactors, on the rich grass pasture, gradually improved in condition, but no immediate improvement of the quality of the milk took place. The continuation of good feeding, after the animals were in good condition, was followed by an improvement both in the quality and the quantity of milk. It has been found that, when there is a low proportion of total solids in milk, the proportions of the various constituents differ from the proportions found in milks which contain a relatively high proportion of total solids. Various feeding experiments are still in progress with regard to these herds.

146. STATISTICAL EXAMINATION OF EXISTING DATA REGARDING VARIATIONS IN THE COMPOSITION OF MILK.

DR. J. F. TOCHER.

The data for statistical analyses were received from the National Institute for Research in Dairying, Reading; Midland Agricultural College; Cheshire School of Agriculture; two private English herds; and one private Scottish herd.

The data from the National Institute for Research in Dairying, Reading, consisted of particulars as to yield of milk, and percentages of butter fat and solids-not-fat of the morning and evening milk of a number of individual cows. The observations were made for a period of about one year.

The data from the Midland Agricultural College consisted of the following particulars: yield, and butter fat and solids-not-fat percentages of the morning and evening milk of the cows of the College herd from March, 1928 to March, 1930. These were accompanied by certain meteorological data such as maximum and minimum temperatures, rain and sunshine throughout the same period.

The data from English herds consisted of records of bulked milk, percentages of butter fat and solids-not-fat during many years, and yield and percentages of butter fat and solids-not-fat for morning and evening milk of 65 cows during the month of April, 1922.

The data from the Scottish herd included yield, percentages of butter fat and solids-not-fat, number of weeks in milk, dates of calving, and length of lactation period of 50 cows for the 1st, 2nd, 3rd, 4th, 5th and 6th lactation period.

With such a mass of data, the work of collation and statistical analysis has been of a laborious character throughout the whole year. The statistical analysis is unfinished. A report on the results will be prepared immediately the work of analysis has been completed.

APPENDIX.

LIST OF DIRECTORS OF RESEARCH INSTITUTES AND HEADS OF ADVISORY CENTRES.

I. RESEARCH INSTITUTES.

A. Soils, Plant Nutrition and Plant Physiology.

Sir E. J. Russell, O.B.E., D.Sc., F.R.S.
Rothamsted Experimental Station, Harpenden, Herts.

W. O. Ogg, M.A., Ph.D.
Macaulay Institute for Soil Research, Craigiebuckler, Aberdeenshire.

R. G. Baskett, Esq., M.Sc., A.I.C.
Chemical and Animal Nutrition Division, Ministry of Agriculture for Northern Ireland, Queen's University, Belfast.

Prof. V. H. Blackman, Sc.D., F.R.S.
Research Institute of Plant Physiology, Imperial College of Science and Technology, South Kensington, S.W.7.

B. Plant Breeding, Crop Varieties and Seeds.

Sir R. H. Biffen, M.A., F.R.S.
Plant Breeding Institute, School of Agriculture, Cambridge.

Prof. R. G. Stapledon, C.B.E., M.A.
Welsh Plant Breeding Station, Agricultural Buildings, Alexandra Road, Aberystwyth.

W. Robb, Esq., N.D.A.
Scottish Society for Research in Plant Breeding, Craigs House, Corstorphine, Midlothian.

Ian W. Seaton, Esq., B.Sc.
Plant Breeding Division, Ministry of Agriculture for Northern Ireland, Stormont, Strandtown, Belfast.

W. H. Parker, Esq., M.A.
National Institute of Agricultural Botany, Huntingdon Road, Cambridge.

T. Anderson, Esq., M.A., B.Sc.
Seed Testing and Plant Registration Station, Department of Agriculture for Scotland, East Craigs, Craigs Road, Corstorphine, Midlothian.

R. Rae, Esq., B.Agr., C.D.A.
Crop and Animal Husbandry Division, Ministry of Agriculture for Northern Ireland, Agricultural Research Institute, Hillsborough, Co. Down.

C. Horticulture and Glasshouse Crops.

Prof. B. T. P. Barker, M.A.
Agricultural and Horticultural Research Station, Long Ashton, Bristol.

R. G. Hatton, Esq., M.A.
East Malling Research Station, East Malling, Kent.

D. Boyes, Esq., M.A.
Horticultural Research Station, School of Agriculture, Cambridge.

W. F. Bewley, Esq., D.Sc.
Experimental and Research Station, Cheshunt, Herts.

Sir A. D. Hall, K.C.B., F.R.S.
John Innes Horticultural Institution, Mostyn Road, Merton, S.W. 19.

D. Entomology and Plant Pathology.

J. C. F. Fryer, Esq., O.B.E., M.A.
Plant Pathological Laboratory, Milton Road, Harpenden, Herts.

R. N. Salaman, Esq., M.D.
Potato Virus Department, Plant Breeding Institute, Cambridge.

Prof. J. W. Munro, M.A., D.Sc.
Biological Field Station, Slough, Bucks.

Mrs. N. L. Alcock.
Plant Pathological Laboratory, Department of Agriculture for Scotland.

S. P. Mercer, Esq., B.Sc., N.D.A.
Seed Testing and Plant Diseases Division, Ministry of Agriculture for Northern Ireland, Queen's University, Belfast.

E. Agricultural Parasitology.

Prof. R. T. Leiper, M.D., D.Sc., F.R.S.
Institute of Agricultural Parasitology, London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, W.C.

T. W. M. Cameron, Esq., M.A., D.Sc., Ph.D., M.R.C.V.S.
Department of Helminthology, Department of Zoology, The University, Edinburgh.

F. Animal Pathology.

F. C. Minett, Esq., D.Sc., M.R.C.V.S.
Research Institute in Animal Pathology, Royal Veterinary College, Camden Town, N.W. 1.

Prof. J. B. Buxton, M.A., F.R.C.V.S., D.V.H.
Institute of Animal Pathology, Cambridge University.

W. H. Andrews, Esq., D.Sc., M.R.C.V.S.
Veterinary Laboratory, Ministry of Agriculture and Fisheries, New Haw, Weybridge, Surrey.

Prof. J. Russell Greig, Ph.D., M.R.C.V.S.
Animal Diseases Research Association, Moredun Institute, Gilmerton, Edinburgh.

H. G. Lamont, Esq., M.Sc., M.R.C.V.S.
Animal Diseases Division, Ministry of Agriculture for Northern Ireland, Stormont, Strandtown, Belfast.

G. Animal Nutrition and Breeding.

F. H. A. Marshall, Sc.D., F.R.S.
Animal Nutrition Institute, School of Agriculture, Cambridge.

J. B. Orr, Esq., D.S.O., M.C., M.A., M.D., D.Sc.
Rowett Research Institute, Bucksburn, Aberdeen.

R. G. Baskett, Esq., M.Sc., A.I.C.
Chemical and Animal Nutrition Division, Ministry of Agriculture for Northern Ireland, Queen's University, Belfast.

C. Crowther, Esq., M.A., Ph.D.
Pig Husbandry Experiment Station, Harper Adams Agricultural College, Newport, Salop.

R. M. Wilson, Esq., B.Sc.
Pig Husbandry Experiment Station, South-Eastern Agricultural College, Wye, Kent.

R. T. Parkhurst, Esq., M.Sc.
National Institute of Poultry Husbandry, Harper Adams Agricultural College, Newport, Salop.

Prof. R. C. Punnett, M.A., F.R.S.
Small Animal Breeding Research Institute, Whittingehame Lodge, Cambridge.

Prof. F.A.E. Crew, M.D., D.Sc., Ph.D., F.R.S.E.
Institute of Animal Genetics, King's Buildings, West Mains Road, Edinburgh.

R. Rae, Esq., B.Agr., C.D.A.
Crop and Animal Husbandry Division, Ministry of Agriculture for Northern Ireland, Queen's University, Belfast.

H. Dairying.

Prof. H. D. Kay, Ph.D., D.Sc.
National Institute for Research in Dairying, Shinfield, nr. Reading.

N. C. Wright, Esq., M. A., Ph.D.
Hannah Dairy Research Institute, Auchincruive, Ayr.

H. G. Lamont, Esq., M.Sc., M.R.C.V.S.
Dairy Bacteriology Division, Ministry of Agriculture for Northern Ireland, Queen's University, Belfast.

I. Agricultural Economics.

C. S. Orwin, Esq., M.A.
Agricultural Economics Research Institute, Parks Road, Oxford.

J. S. King, Esq., Ph.D.
Farm Economics Department, Department of Agriculture for Scotland, York Buildings, Queen Street, Edinburgh.

D. A. E. Harkness, Esq., M.A.
Agricultural Economics Division, Ministry of Agriculture for Northern Ireland, Queen's University, Belfast.

J. Preservation and Transport.

Sir W. B. Hardy, M.A., LL.D., F.R.S.
Low Temperature Research Station, Cambridge.

F. Hirst, Esq., M.Sc., A.R.C.S. (Resident Director).
Fruit and Vegetable Preservation Research Station, Chipping Campden, Glos.

K. Agricultural Engineering.

H. J. Denham, Esq., M.A., D.Sc.
Institute of Agricultural Engineering, 37a, St. Giles, Oxford.

II. ADVISORY CENTRES.

Prof. J. A. Hanley, Ph.D.
Armstrong College, Newcastle-on-Tyne.

Prof. B. T. P. Barker, M.A.
Agricultural and Horticultural Research Station, Long Ashton, Bristol.

Prof. F. L. Engledow, M.A.
School of Agriculture, Cambridge.

C. Crowther, Esq., M.A., Ph.D.
Harper Adams Agricultural College, Newport, Salop.

Prof. R. S. Seton, B.Sc.
Department of Agriculture, The University, Leeds.

J. Orr, Esq., M.A.
Victoria University, Manchester.

Prof. S. H. Gaiger, F.R.C.V.S.
The University, Liverpool.

T. Milburn, Esq.
Midland Agricultural College, Sutton Bonington, Loughborough.

Prof. J. A. S. Watson, M.A.
School of Rural Economy, Parks Road, Oxford.

Prof. H. A. D. Neville, M.A., B.Sc.
The University, Reading.

D.R. Edwardes-Ker, Esq., O.B.E., M.A.
Seale-Hayne Agricultural College, Newton Abbot, Devon.

R.M. Wilson, Esq., B.Sc.
South Eastern Agricultural College, Wye, Kent.

Prof. J. J. Griffith, B.Sc.
Agricultural Department, University College of Wales, Alexandra Road, Aberystwyth.

Prof. R. G. White, M.Sc.
Department of Agriculture, University College of North Wales, Memorial Buildings, Bangor.

Principal A. H. Trow.
University College of South Wales and Monmouthshire, Cathays Park, Cardiff.

Prof. J. Hendrick, B.Sc., F.I.C.
North of Scotland College of Agriculture, Marischal College, Aberdeen.

E. Shearer, Esq., M.A., B.Sc.
Edinburgh and East of Scotland College of Agriculture, 13, George Square, Edinburgh.

W. G. R. Paterson, Esq., B.Sc., N.D.A.
West of Scotland Agricultural College, 6, Blythswood Square, Glasgow.

III. OTHER CENTRES OF INVESTIGATION.

The Principal.
East Anglian Institute of Agriculture, Chelmsford.

Prof. C. K. Tinkler.
King's College of Household and Social Science, Campden Hill Road, London, W.8.

Prof. E. S. Goodrich, M.A., D.Sc.
Department of Zoology and Comparative Anatomy, University Museum, Oxford.

R. L. Harrow, Esq.
Royal Horticultural Society's Gardens, Wisley, Ripley, Surrey.

Dr. O. C. Bradley, M.D., D.Sc.
Royal (Dick) Veterinary College, Edinburgh.

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